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Salute TO A PIONE

The
LUCAS GUSHER
Spindletop, Texas. Depth 1,848'. Photo by Trost Studio, Port Arthur, Texas, January 10, 1901.

LUCAS GUSHER MEMORIAL
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Pierre Bourdelle, Sculptor.
Premier Granite Quaries, Inc., Contractors.

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It was the first important well drilled with rotary tools; it proved salt dome drilling; marked the Gulf Coast as a major production area; started the State of Texas on a long and productive career in petroleum; and in various ways marked the beginning of a new era in oil. Oil is still produced on the [illegible] which has been [illegible] Oil Company for [illegible]

This grand old veteran will be signally honored at Beaumont [illegible] next month. A 54-ft. monument built of Texas Granite over the site of the Lucas Gusher by contributions from various members of the petroleum industry, will be unveiled during the convention of the Mid-Continent Oil & Gas Association. The proposed memorial is illustrated above.

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September, 1941

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MEMBER A. B. C.—A. B. P. (The articles in *The Petroleum Engineer* are indexed in the *Industrial Arts Index*, New York, N. Y.)

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The Course of Oil

by K. C. SCLATER

Meeting National Needs

Petroleum being a key resource in the National Defense program, the necessity of maintaining and insuring an adequate supply of crude petroleum and refined products for national needs is obvious. The petroleum industry of the United States must be prepared to supply an increased national demand. It has been estimated that the consumption during the coming year will be fifteen percent greater than this year. Of the industry's ability to meet this demand there is no need for apprehension, provided the tools, equipment, and essential material are available.

Besides increasing the current rate of production to meet an anticipated greater demand, there is the further necessity of maintaining adequate reserves. The discovery of new reserves is still subject to too much uncertainty to allow exploration and wildcat drilling to lag. Recognition of this fact and the necessity of maintaining adequate reserves has been repeatedly emphasized by the PCO. Only last week, Ralph K. Davies, Deputy Petroleum Coördinator, in a statement made before the Senate committee investigating the petroleum situation, asserted that, "Since the production of crude oil is the foundation of the entire petroleum industry it must be ever remembered that sustained production of petroleum depends entirely upon a vigorous discovery and development program that finds and makes available new reserves of oil and gas at a rate not less than that at which older reserves are being produced and consumed."

National Defense requirements have made necessary the curtailment of steel and special metals so essential in the manufacture of production and refining equipment. The industry has been told that it will have to get along with seventy percent of normal steel needs. To put it bluntly, the industry must see to it that the increased national demand for petroleum and its products is met, even in the face of this stiff reduction in available equipment and supplies. The industry may as well realize that a more prudent employment of tools, equipment, and material in drilling and producing operations will be necessary — may even become compulsory. Deputy Petroleum Coördinator Davies has stated that, "If only seven tons of steel are available for each ten tons that the industry desires, it will be necessary to spend the seven tons so efficiently that it will do the work of ten."

Brine in Flooding Operations

Brine as a flooding medium in the secondary recovery of oil has proved feasible in the shallow "shoestring" area of eastern Kansas and northeastern Oklahoma. According to a study made by the U. S. Bureau of Mines to determine the feasibility of using brine as a flooding medium to increase the recovery of oil from partly depleted oil sands, "The results indicate that brine, when properly conditioned, is effective as a flooding medium, also that it is advisable to employ brine for flooding in areas where fresh water is limited or where fresh-water supplies might be contaminated by the brine produced in flooding. The use of either fresh water or brine for flooding presents treatment problems, and under certain conditions the proper treatment of brine might be less complicated than that of fresh water.

"Analysis of the oil production and core data of one lease indicates that 8.7 percent of the original volume of oil in the formation was recovered before flooding and 21.3 percent to November 1, 1940, by flooding. The average ratio of the volume of brine injected to the volume of oil produced on lease C was approximately 14 to 1 from the time flooding was begun until November, 1940. The Hempel distillations and the specific gravity and viscosity of a large number of oil samples taken at three intervals over a 20-month period show only slight changes in the properties of the oil produced. This fact indicates that the injected brine gradually was flooding the less permeable sections of the formation and that it was not supersaturated with bicarbonates to such an extent that precipitation of carbonates and sealing of part of the formation were occurring. The results of a survey show that the injected brine did not increase the salt content of the produced oil."

The study is the subject of a comprehensive report recently published: "Use of Brine in a Kansas Field for Secondary Recovery of Oil" by C. J. Wilhelm, Sam S. Taylor, W. C. Holliman, and E. O. Owens; U. S. Bureau of Mines Report of Investigations 3573.

A note of warning is sounded by the authors, who caution that the results discussed apply only to the project studied, and that the development and operation described should not be used as a model for other flood projects, even though conditions appear to be similar.

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Highlights IN OILDOM

Set Ceiling Prices for Pennsylvania Crude Oil

The Office of Price Administration and Civilian Supply, in a recent order, directed that the price of Pennsylvania crude oil be restored to the prices existing prior to August 14. This rescinded the price increase of 23 to 25 cents a bbl. posted on that date.

The order, characterizing the advance as inflationary, stated that its inquiry into the situation "has failed to demonstrate an adequate economic basis for these increases. No showing has been made that labor or material cost increases, if any have occurred, have not already been met by the prior increases in prices."

The order disposes of the argument that the price increase would stimulate drilling, resulting in an increased supply of this grade of oil, in the following words:

"But the anticipated amount of new drilling was uncertain and was one of the facts under investigation by this Office. Moreover, the increased prices would apply to the entire present production of 76,000 bbl. per day, as well as to the small volume which new drilling would yield in the future."

The order established a ceiling price of $2.75 per bbl. for Bradford crude oil; $2.40 per bbl. for Southwest Pennsylvania crude oil; $2.34 per bbl. for Eureka, and $2.30 for Southeastern Ohio crude oil. Top prices for various qualities between Oil City and Titusville, Pennsylvania, range from $2.63 to $2.69 per bbl.

To Curtail Unnecessary Drilling in Proved Fields

Curtailment of unnecessary drilling in proved oil fields has been asked by Ralph K. Davies, deputy defense petroleum coördinator. At the same time, however, he urged the continuance of wildcat drilling at an unabated rate, asserting that the search for new fields should go forward to maintain a discovery rate that will avoid depletion of petroleum reserves and the overproduction of existing fields.

Davies said an end to competitive drilling in established fields is absolutely essential at this time because of a serious, growing shortage in oil-well supplies, such as steel and other metals and materials. Demands of the defense program, he said, are responsible for this deficiency.

Davies issued the following statement:

"In view of the obvious shortages of oil-well supplies resulting from the necessities of the defense program, the oil industry and the state regulatory bodies having control of well spacing patterns must realize that further drilling of unnecessary wells is against the public interest and must be stopped.

"Newly developing fields must be drilled on the widest feasible spacing patterns and reasonable bottom-hole pressures must be maintained in order to prevent underground waste of oil which otherwise may be recoverable by closer drilling when the emergency has passed and oil-well supplies are again plentifully available.

"In this crisis the Nation cannot allow material to be wastefully used for town lot drilling nor for additional wells in fields already adequately drilled.

"Wildcat drilling must continue at an unabated rate, but we can afford to expend material for development drilling. only in exchange for substantial additions to our reserves."

New Proration Plan for Panhandle

Wells in the Panhandle area of Texas, beginning October 1, will be permitted to produce according to a formula based 25 percent on acreage and 75 percent on wells. The order, announced by the Texas Railroad Commission, will replace one assigning a 20-bbl. allowable to Panhandle wells. Under the new plan, commission members said, wells capable of producing more than 20 bbl. per day will be given larger allowables.

Suggests Brine for Water-Flooding

Brine, or salt water, can be used as effectively as fresh water for flooding partly depleted oil sands in order to promote the recovery of petroleum from certain oil wells, and, at the same time, its use prevents contamination of fresh water streams and harm to agricultural lands, according to studies made by the U. S. Bureau of Mines in coöperation with the Kansas State Board of Health.

In a report submitted to Secretary of the Interior Harold L. Ickes, the Bureau declared that a survey made of oil production in the shallow "shoe-string" area of eastern Kansas and northeastern Oklahoma indicated that (1) brine produced from subsurface formations may be used successfully in place of fresh water as a flooding medium in the secondary recovery of oil; (2) it is advisable to use brine for flooding in areas where fresh water is limited or where contamination of fresh water supplies is probable; and (3) under certain conditions, the proper treatment of brine would be less complicated than that of fresh water.

The value of water-flooding as a means of increasing the ultimate recovery of oil has been realized for a number of years because of its successful operation in many of the older oil-producing areas. In recent years water-flooding has been adopted in various Mid-Continent oil-producing areas, especially eastern Illinois, eastern Kansas, and northeastern Oklahoma. In many of these areas, however, progress in the development of water-flooding projects has been hampered by the limited amount of fresh water available, and by the fact that the disposal of the brine produced with the oil once a project is in operation also presents a problem. The use of brine has resolved these problems on the project studied by the Bureau.

Reduced Rates on Drilling Equipment

Reductions averaging 25 percent in railroad rates on oil-well drilling equipment moving in Texas have been obtained by the Texas Mid-Continent Oil and Gas Association from the Texas Railroad Commission. The new rates, which include reductions of as much as 44 percent, became effective August 30.

Under the Texas Mid-Continent's petition as granted by the railroad commission, the new rates apply on used oil-well supplies, tools, machinery, and equipment that is an essential part of an oil-well drilling outfit. This includes pipe, iron or steel tank, knocked down, or one tank set up, structural steel, wire rope, lumber and timbers, one toolhouse, box of tools, and other articles properly belonging with such an outfit. The commission order provides for shipment in mixed carloads with one rate for the aggregate of all the articles making up a drilling rig.

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4 Spacing band centers glass and prevents contact with metal.

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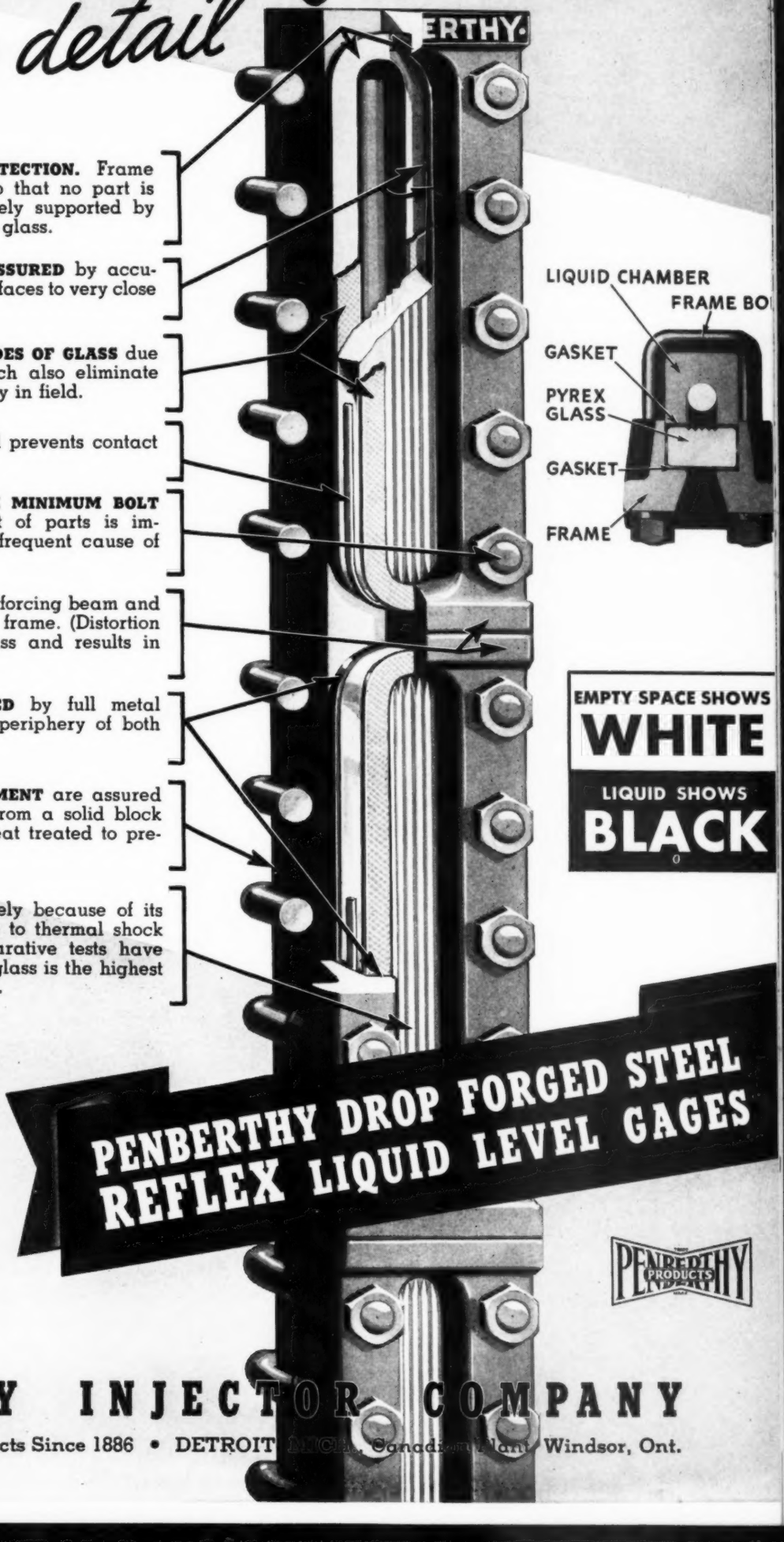

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MAJOR *Oil Field* ACTIVITIES

HARLAN COUNTY, Nebraska, apparently has a new field in Veedor Supply Company's Battin No. 1, 15-2n-18w, which was drilled to a depth of 4204 ft. in the Arbuckle lime. Casing set to 3610 ft. was ripped between 3541-92 ft. opposite the Kansas City-Lansing lime and a rainbow showing of oil was obtained.

A new Wilcox sand pool has been opened by Phillips Petroleum Company, Ross Oil Company, and Fidelity Royalty Company in southwestern Creek County, Oklahoma. The well, Starr No. 1, SW 7-15-8, flowed 162 bbl. of 41-gravity oil in 24 hr. while cleaning-out after a 40-quart shot from 3798 to 3816 ft.

Illinois has recently opened four new pools in Richland, Wayne, and Hamilton counties. In Wayne County Olson Drilling Company's Porter No. 1, C W½ NW SE of 36-1n-6e, flowed 546 bbl. of oil naturally the first 24 hr. from the McClosky lime at a depth of 3194-97 ft. Treatment with 2000 gal. of acid caused the well to increase flow to 680 bbl. per day through the tubing.

In Richland County C. R. Craft's Daube No. 1, 8-2n-14w, flowed 435 bbl. of oil and from 2 to 5 percent water the first 16 hr. through ¾-in. tubing choke from the McClosky at 3144-69 ft.

The Ohio Oil Company's Koerge No. 1, C S½ SE NW of 29-2n-14w, several miles south of the Craft well, drilled into the McClosky at a depth of 3117-29 ft. and the well tried to blow in, but was placed under control.

Hamilton County's pool was opened by Kingwood Oil Company's Johnson No. 1, NE SE NE of 14-6s-5e. The well was drilled to the Aux Vases sand, discovered in the Hardin pool. Shot with 70 quarts it flowed 938 bbl. in 24 hr.

Western Lea County, New Mexico, appeared to have a new oil field when Richmond Drilling Company's Shell Oil Company, Inc.-State No. 1, between the Maljamar and Vacuum fields, found free oil from 4572-79 ft. The gas volume was estimated at 100,000 cu. ft. per day.

The 27th discovery in the State of Kansas for the year was brought in by the Phillips Petroleum Company and Trees Oil Company No. 1 Bruce, NWC NE, 9-30-4e, a few miles northwest of the Rock Pool in Cowley County, south-central Kansas. Production is from the Burbank sand at 3315 ft.

A temporary potential of 87 bbl. per day was given the well by the state conservation department.

Gulf Oil Corporation has opened a new producing area with its wildcat test M. E. Picou No. 1 in the Lapyrouse prospect, 70-20s-18e, Terrebonne Parish, Louisiana. The well flowed 12 bbl. of oil an hr. through perforations at 10,942-46 ft. The gas-oil ratio was 7500 to 1 with a slight show of water in production. This well was drilled to a total depth of 12,149 ft.

Southern Hidalgo County, Texas, has a new gas field approximately 1½ miles southeast of the McAllen gas distillate field discovery well. The wildcat well was drilled by W. R. Davis, Inc. A reported depth of 8575 ft. with casing set at 8200 ft. and an open flow of gas of 21,500,000 cu. ft. per day was credited to the well. The well is the Arizona-Texas Citrus Company No. 1.

AVERAGE CRUDE OIL PRICES

California		Louisiana	
Kettleman Hills	$1.23-1.29	Rodessa	.88-1.20
Playa Del Rey	.80- .87	Gulf Coast	.95-1.48
Coalinga	.73-1.13	North Louisiana	1.20-1.30
Wilmington	.68-1.24		
Montana	1.00-1.15	Illinois	1.22-1.37
Wyoming	.47-1.15	Kentucky	1.32-1.43
Colorado	.95- .97		
New Mexio	.70-1.15	Indiana	1.22
Texas		Ohio	
North Central	.68-1.27	Lima	1.05
Panhandle	.70-1.15		
West Texas	.70-1.12	Michigan	1.24-1.44
Gulf Coast	.95-1.48		
Darst Creek	1.14	Pennsylvania	
East Texas	1.27	Bradford	2.75
Talco	.79	Southwest	2.40
Kansas	.70-1.25	Eureka	2.34
Oklahoma	.70-1.25	Buckeye	2.30
Arkansas	.68-1.30	Corning	1.31

DAILY AVERAGE CRUDE OIL PRODUCTION
Data Supplied by A.P.I.

(Figures in bbl. of 42 gals. each)

	[1]B. of M. Calculated Requirements (August)	Week Ended Aug. 30, 1941	Week Ended Aug. 2, 1941	Week Ended Aug. 31, 1940
Oklahoma	492,400	[2]427,650	417,050	420,550
Kansas	240,800	[2]254,300	235,500	176,900
Nebraska	4,400	[2] 7,350	5,050	150
Panhandle Texas		80,300	80,750	65,000
North Texas		100,600	99,900	95,250
West Central Texas		30,700	29,650	28,950
West Texas		274,350	221,650	195,900
East Central Texas		84,950	79,400	72,100
East Texas		369,550	298,550	374,900
Southwest Texas		219,200	180,250	183,350
Coastal Texas		289,650	242,350	189,600
TOTAL TEXAS	1,361,600	1,449,300	1,232,500	1,205,050
North Louisiana		79,900	78,550	64,600
Coastal Louisiana		254,000	240,350	210,300
TOTAL LA.	324,500	333,900	318,900	274,900
Arkansas	80,700	74,650	73,300	73,750
Mississippi	25,200	[2] 50,600	47,750	21,800
Illinois	390,100	391,100	357,650	377,800
Indiana	22,100	[2] 20,250	20,350	18,450
Eastern (Not incl. Ill. & Ind.)	98,900	95,150	94,800	88,850
Michigan	36,000	47,250	42,450	53,350
Wyoming	85,000	84,750	82,600	72,150
Montana	20,000	20,350	20,400	17,450
Colorado	4,400	3,900	4,000	3,500
New Mexico	112,900	113,800	109,750	100,700
TOTAL EAST OF CALIF.	3,299,000	3,374,300	3,062,050	2,905,350
California	641,000	630,400	633,200	596,000
TOTAL U. S.	3,940,000	4,004,700	3,695,250	3,501,350

[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of August. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

[2]Oklahoma, Kansas, Nebraska, Mississippi, and Indiana figures are for week ended 7 a. m. August 27.

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ADOPTION OF JELFLAKE* in drilling and completion practices confirms the logic of that old "saw" about an ounce of prevention being worth a pound of cure. When used in time JELFLAKE is good insurance against costly mud or cement losses. Through its use marked savings in drilling time and elimination of equipment losses have been obtained by operators. So vital are the JELFLAKE advantages that it is being used in practically every rotary drilling area of the United States, New Zealand, Mexico, Trinidad, Cuba, Peru, Venezuela and other foreign countries.

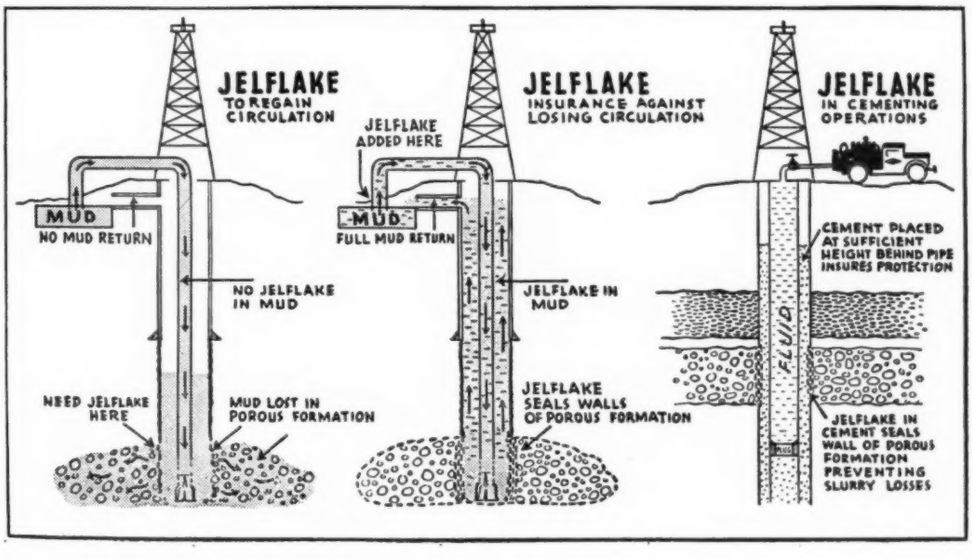
JELFLAKE is a chemically inert, thin, fragmented film substance having enormous area per unit of weight and high tensile strength. It is unaffected chemically by water, mud or high bottom hole temperatures and will not ball up, accumulate or bridge in the hole. JELFLAKE mixes easily with drilling mud or cement and stays in suspension, even when the movement of the fluid column stops. It flows evenly through drill pipe, float equipment and special cementing tools.

JELFLAKE stops the loss of drilling mud or cement slurry in "thief formations" by building up a strong, impervious wall as the fragmented film substance strains out and lodges upon the formation. This JELFLAKE wall supports high differential fluid pressures and cannot be penetrated by drilling mud or cement slurry.

JELFLAKE has proved to be more economical than other materials for restoring lost circulation. It is readily available—all Dowell treating stations and numerous oil field supply stores carry ample stocks. It is packaged in convenient form for ease in handling. Samples of JELFLAKE and special literature can be obtained from any Dowell representative, or by writing to Dowell Incorporated, Kennedy Building, Tulsa, Oklahoma.

*Trade Mark Reg. U.S. Pat. Off.

Feeding JELFLAKE into the mechanical mixing hopper on a Dowell cementing truck.



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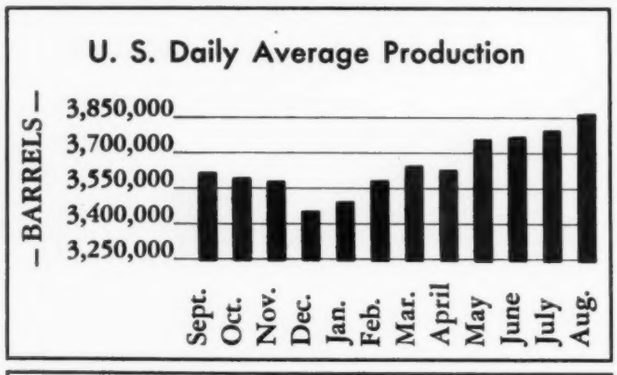
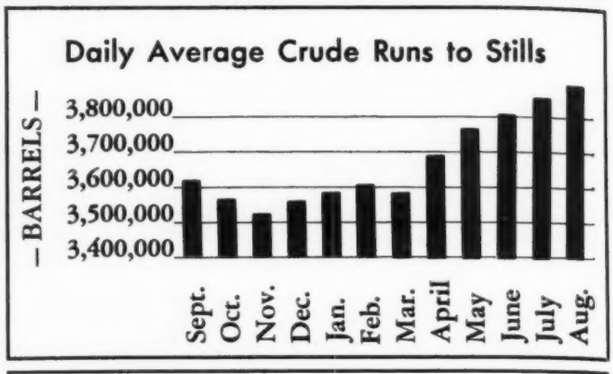
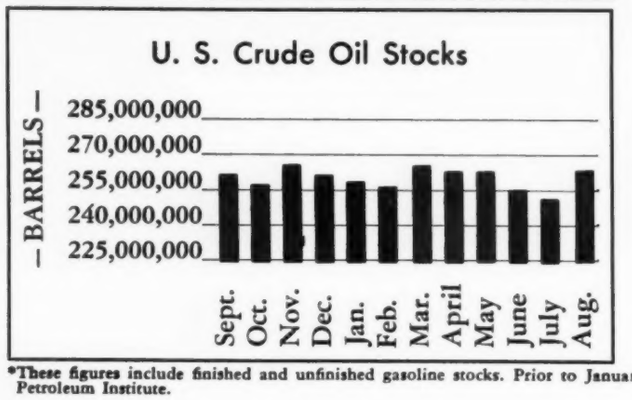
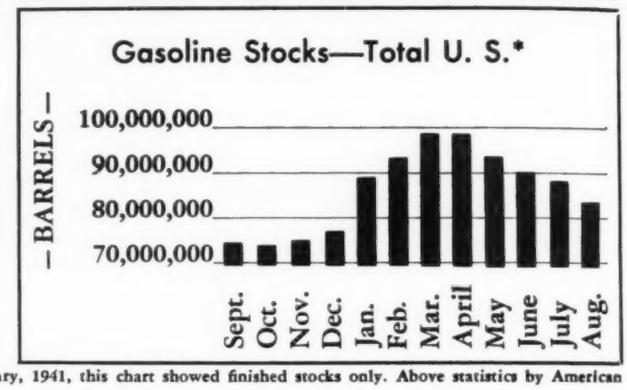
PETROLEUM *Statistics* AND FIELD *Operations*









*These figures include finished and unfinished gasoline stocks. Prior to January, 1941, this chart showed finished stocks only. Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for August, 1941

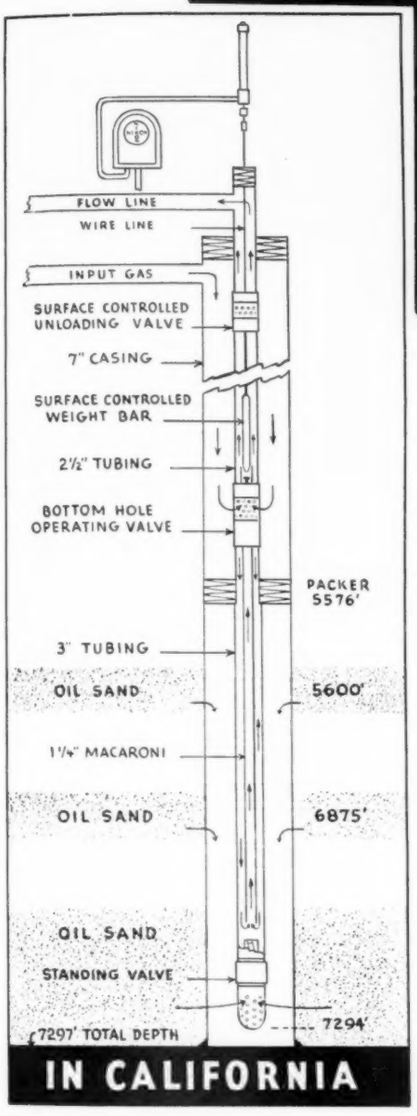
Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	101	84	16	33	3500-3700	2	40	Rotary
Gaines County	15	15	6	14	4400-5584	2	22-35	Rotary
Hockley County	66	65	12	31	4800-6850	2	20-30	Rotary
Ector County	30	30	12	30	3675-4377	2 or 3	32-36	Rotary
Panhandle	86	84	29	72	1700-3900	2	40	Rot.-Cab.
Nueces County	42	39	9	23	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	30	30	6	18	3730-3935	2	42-43	Rot.-Cab.
Hawkins Field	19	19	9	17	4495-4912	2	19-29	Rotary
OKLAHOMA								
Okfuskee County	22	15	9	14	2150-4125	2 or 3	38	Rotary
KANSAS								
Russell County	42	34	6	15	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	11	3	4	6	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	29	18	10	18	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	407	297	397	140	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	24	21	9	14	3150-4030	2	30-34	Rot.-Cab.
CALIFORNIA								
Kern County	34	31	14	23	1840-11,450	3 or 4	14-30	Rotary
Wilmington	23	23	6	7	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for August, 1941

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1940 (In Barrels)
	August	July	August	July	August	July	August	July	August	July	
Arkansas	15	16	7	5	23	20	9	11	17	38	25,699,000
California	104	130	90	77	95	136	94	100	149	161	224,029,000
Colorado	1	1	1	1	....	....	7	10	5	18	1,369,788
Illinois	407	448	297	338	460	518	397	292	140	148	146,572,938
Indiana	53	49	33	21	61	49	26	22	49	46	4,946,384
Kansas	190	255	139	68	210	230	27	35	198	295	65,602,452
Kentucky	24	26	14	12	25	26	12	7	57	62	5,282,335
Louisiana	120	164	84	54	146	187	41	47	234	261	103,738,728
Michigan	67	89	40	32	74	98	33	40	118	133	19,768,984
Mississippi	16	17	12	1	....	....	5	8	27	31	4,313,159
Montana	19	11	17	5	....	....	9	6	25	23	6,663,872
Nebraska	6	8	3	5	7	9	7	5	12	14	267,533
New Mexico	37	24	19	10	58	47	23	24	80	76	38,893,898
New York	81*	133*	....	....	....	....	17	23	56	88	4,240,441
Ohio	130	166	88	40	....	....	42	51	138	192	3,132,280
Oklahoma	201	211	57	46	249	262	60	68	197	203	152,516,049
Pennsylvania	400*	287*	213	8*	....	....	38	17	115	85	17,987,217
Texas	907	1126	718	245	1365	1439	754	813	1542	1736	490,101,261
West Virginia	55	64	50	11	....	....	18	21	119	129	3,586,653
Wyoming	18	10	15	1	....	....	11	12	16	11	25,863,538
Total	2819	3379	1874	920	4647	3021	1459	1612	3294	5262	1,344,576,159

*Includes water-intake and pressure wells.

WE RELIEVED THE PRESSURE .. and got production from all 3 formations



.. a Typical Example of NIXON GAS-LIFT ADAPTABILITY

This California operator had a real production problem. Producing zones were flowing through perforated casing at 5600 feet; 6875 feet and bottom 7297 feet. But with ordinary, open gas-lift, when production pressure was applied to casing—it offset formation pressure and the top formation ceased flowing.

Could the Nixon Gas-Lift solve this problem? It certainly could—and did—with a closed intermittent sub-packer installation.

A Nixon bottom hole operating valve was set at 5566 feet, with 3-inch tubing extending to bottom where a standing valve was set at 7290 feet. A Hook Wall Packer, set at 5576 feet, between operating valve and top formation, seals off all three producing formations from operating gas pressure.

Inside the 3-inch tubing, from operating valve to a point just above standing valve there is a 1¼-inch macaroni string. Fluid-lifting pressure is intermitted through the bottom hole operating valve, into annulus between macaroni string and tubing, to force fluid up through the macaroni string.

This installation is actually producing from about 7 feet off bottom, while packer and operating valve are 1721 feet above. Since this installation production has increased from 55 to 375 barrels daily.

Nixon gas-lift engineers are helping scores of operators improve the efficiency and lower the cost of producing their wells. Discuss your production problems with them.

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MAJOR *Pipe Line* ACTIVITIES

RIGHT-OF-WAYS are being surveyed for the construction of an 825-mile, 20-in. pipe line from the Monroe field of northern Louisiana to West Virginia by Hope Natural Gas Company of New Jersey. It is estimated the line will cost $25,000,000 including pumping equipment.

Sheehan Pipe Line Construction Company has contracted to lay 10 miles of 12-in. line from Albion to Centerville, Illinois, and 8 miles of 10-in. from Flat Rock to Stoy, Illinois, for the Illinois Pipe Line Company. H. C. Price Company of Bartlesville, Oklahoma, has been awarded the contract for electric welding of the lines.

Purchase of right-of-way for a 16-in. line from the Cement pool, Caddo County, Oklahoma, for natural gas by the Cities Service Gas Company, Bartlesville, Oklahoma, has been reported.

The line would be 55 miles long with a capacity of about 90,000,000 cu. ft. per day. It is expected to cost about $750,000. At Oklahoma City, the line would connect with the company's 20-in. line, which extends through northern Oklahoma and into Kansas.

Construction of six loops to increase the flow of Gulf Refining Company's pipe lines has been announced. Work has begun on the first of the loops near Anderson, Missouri. Fifty-six cars of pipe have been received for the line, which extends from Perryman, Oklahoma, to Dublin, Indiana. At Dublin the line connects with other Gulf lines to the eastern cities of Cincinnati and Cleveland, Ohio.

The six loops are expected to increase the capacity of the line at least 25 percent.

Completion of a 125-mile pipe line of 14-in. diameter from the Joaquin-Logansport gas-distillate field of northeastern Shelby County, Texas, and southeastern De Soto Parish, Louisiana, to the Monroe gas field of central Louisiana, has been announced by The Southern Production Company, Birmingham, Alabama.

The company, a subsidiary of The Southern Natural Gas Company, is completing final connections with the company's trunk line from Monroe to Birmingham. The gas will be used to fill defense industry contracts.

Contract to build a 19-mile, 6-in. line into the Abell field of Pecos County, Texas, from Crane station has been awarded to Teking Construction Company, Hobbs, New Mexico, by The Texas-New Mexico Pipe Line Company. A 4-in. lateral line will connect the Permian lime area east of Abell.

President Franklin D. Roosevelt has twice issued proclamations to pipe line companies giving them the authority to acquire, by eminent domain, the land required for construction of pipe lines classified as vital to national defense through powers granted him by the recent enactment of the Cole Bill.

Issuance of a proclamation by the President in exercising the eminent domain power granted by Congress declares the President's finding that the pipe lines planned by the companies were necessary for national defense and would set forth the terms and conditions under which the project would be constructed, completed, owned, operated, and maintained.

The President issued his first proclamation in connection with the Plantation Pipe Line Company's line from Baton Rouge, Louisiana, to Greensboro, North Carolina. Plantation filed the first request for right-of-way for the 1261-mile line that is to cost an estimated $30,000,000 and will tend to alleviate the shortage of petroleum products on the Atlantic seaboard.

It has been reported that the line may be completed in December with legal obstacles removed.

President Roosevelt's second proclamation was issued to permit the Southeastern Pipe Line Company of Delaware to obtain the land necessary to complete the pipe line from Port St. Joe, Florida, to Chattanooga, Tennessee. This line, 500 miles in length, had been completed for a number of months except for right-of-ways across railroads. With power to obtain the right-of-ways now granted, it is expected that the line will be completed in the near future and placed in operation.

John Hancock, secretary of the Public Service Commission at Cheyenne, Wyoming, has issued a certificate of convenience and operation to W. T. Ross of Riverton and Minneapolis, Minnesota, to lay 34 miles of 8-in. pipe line from the Maverick oil field in Fremont County, Wyoming, to the rail head at Shoshoni on the Chicago Northwestern and the rail head at Bonneville on the Burlington. Also included was a 4-mile extension to the Circle oil field. The Maverick field was recently revived after being shut down since 1920.

Eleven large oil companies have submitted plans for the 1820-mile pipe line from East Texas to the New York area to Petroleum Coördinator Harold L. Ickes. The line, to transport 250,000 bbl. of crude oil per day into eastern refineries, has been planned to cost $80,000,000 instead of the first estimate of $70,000,000.

In the plan submitted, the 11 companies propose the organization of two jointly owned and privately financed pipe line corporations, namely: National Defense Pipe Lines, Inc., and Emergency Pipe Lines, Inc. The first corporation would take care of the construction and operation of the line from near Shreveport to New York. The latter corporation would build and operate the 65-mile, 22-in. line from the end of the main line near Shreveport to the East Texas fields.

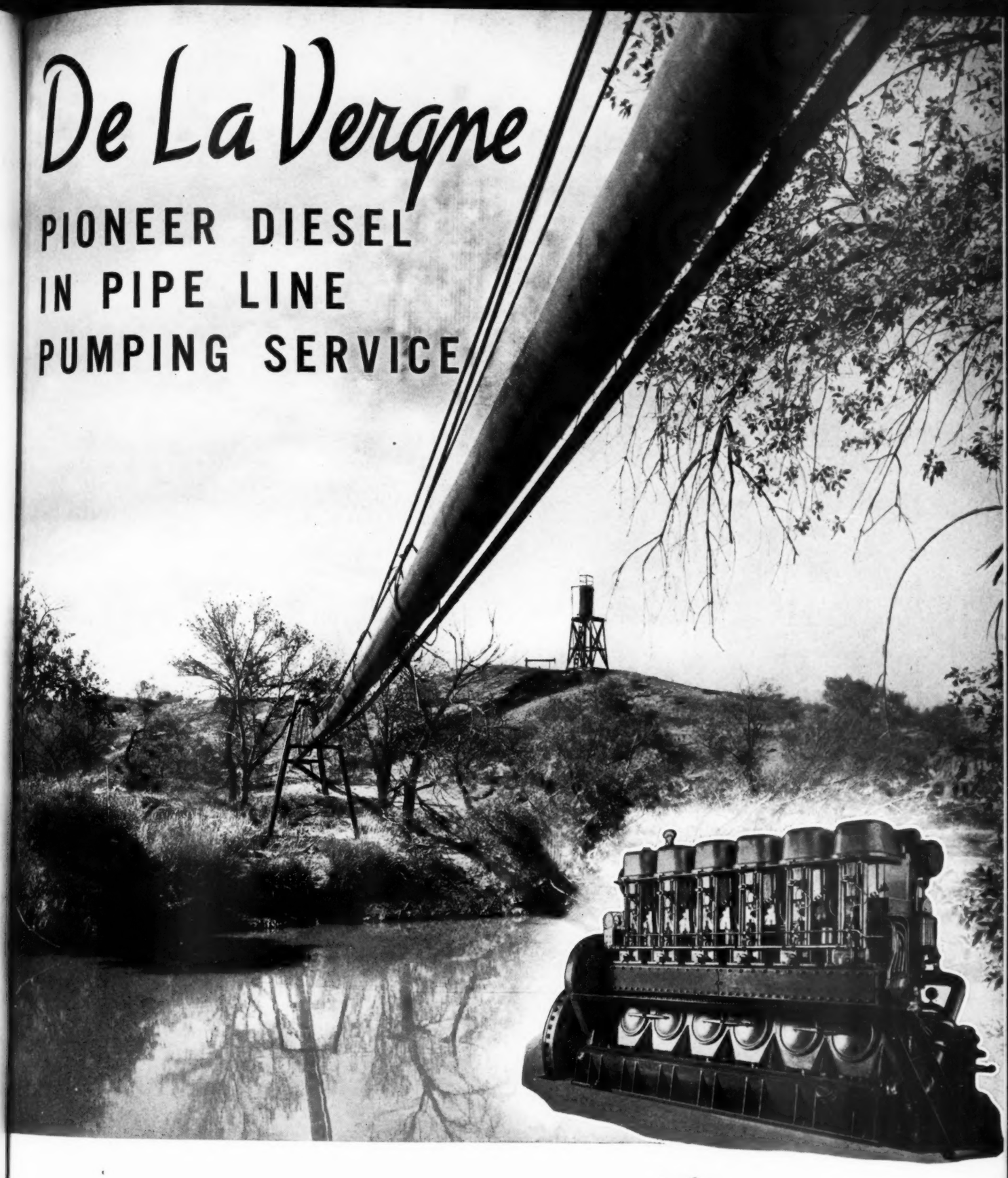
A 22-in. line from west of Shreveport, Louisiana, near the Texas border to Salem, Illinois, a distance of about 490 miles, was proposed in the plan. From Salem to Wood River, Illinois, a 16-in. connecting line would tap facilities carrying oil from Oklahoma, Kansas, Texas, Mid-Continent, and Illinois areas, a distance of about 65 miles. From the junction of the first two lines, a 24-in. line would carry the crude oil to the New York and Philadelphia, Pennsylvania, refining areas, a distance of about 1200 miles.

The line, the longest single crude oil line in the world, would be privately financed. National Defense Pipe Lines, Inc., Ickes said, would borrow 80 percent of the estimated costs by private placement of notes maturing over a five-year period. The remainder would be acquired through issuance of junior securities or capital stock that would be purchased by the participating companies.

Companies participating in the plan are Standard Oil Company of New Jersey, Consolidated Oil Corporation, Sun Oil Company, Atlantic Refining Company, Cities Service Company, Socony-Vacuum Oil Company, Inc., Tide Water Associated Oil Company, Gulf Oil Corporation, Shell Oil Company, Inc., and the Pan-American Petroleum and Transport Company.

De La Verqne

PIONEER DIESEL IN PIPE LINE PUMPING SERVICE



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MAJOR *Refining* ACTIVITIES

Percent Refining Capacity Operated

Western Division, 83.5 Percent **Central Division, 98.9** **Eastern Division, 97.2**

THE Sinclair Refining Company plans addition of an aviation gasoline plant at its Houston, Texas, refinery. Construction of the plant has been approved by Sinclair officials. The plant will be built as quickly as the plans can be drawn and priorities of materials arranged. Capacity and cost of the proposed plant will be determined chiefly by the availability of materials.

Sinclair's only other aviation gasoline plant is at its East Chicago refinery.

Humble Oil and Refining Company will place its large Baytown Ordnance Works in operation on October 1, one month ahead of schedule. The plant, costing $11,857,000, will produce toluene from raw refinery gases for use in making high explosives.

A contract between Humble and the federal government included the following provisions: (1) That Humble would construct the plant at a cost of $10,760,000 and operate it on a cost-plus-fixed-fee basis, the title to the plant remaining with the government; (2) that the company would place additional equipment in its existing plant at a cost of $1,097,000, the company supplying the funds for the equipment with the government to repay the cost over a period of 5 years; (3) at the end of the 5 years' period the company will have the option to purchase the equipment at cost less some prearranged rate of depreciation, or alternatively, at some negotiated sum. Otherwise the property title will be transferred to the government.

W. E. Anderson, organizer, president and general manager of the Naph-Sol Refining Company of Muskegon, Michigan, has confirmed the purchase by his company of The Black Gold Refining Company's refinery at Oklahoma City, Oklahoma. The refinery has a 2000-bbl. per day skimming and cracking capacity. The Naph-Sol refinery in Michigan has a 3500-bbl. per day skimming and 1500-bbl. per day cracking unit. Both refineries produce gasoline, fuel oil, naphtha, kerosine, furnace oils, and other products.

Construction began September 15 on a hydrogen sulphide removal plant at Eunice, New Mexico, for the Skelly Oil Company. Contract for building the plant was awarded to the engineering and construction division of Frick-Reid Supply Corporation. The plant is designed to process 20,000,000 cu. ft. of gas per day and will use the Koppers Company Seaboard Process.

The Kendall Refining Company of Bradford, Pennsylvania, has purchased the Bradford Oil Refining Company plant, which has been shut down for a number of months because of low prices for by-products. Kendall paid a reported $305,500 for the Bradford plant and is expected to operate it in connection with its own holdings in northwestern Pennsylvania.

A 1500-bbl. refinery is being constructed at Reed City, Michigan, by the Osceola Refining Company to provide the Reed City field a refinery outlet. Operation will begin about October 1. The shut down plant of the Glenco Refining Company at Bloomington, Michigan, was purchased and the equipment moved to Reed City. Weber Oil Company has contracted to supply the refinery with crude oil.

Head of the newly organized company is Ray Andres, who is also president of the Sweet Oil Refining Company. John P. O'Neill and Robert Fish, both of Big Rapids, Michigan, are vice-president and secretary-treasurer, respectively.

Formerly with the Old Dutch Refining Company, F. J. McCormick, who is in charge of construction, will continue as superintendent upon completion of the plant.

Addition of a polymerization unit to its Laurel, Montana, refinery has been announced by the Independent Refining Company. The company was one of the first to successfully apply a cracking process to Oregon Basin crude oil, it is stated. A double cracking process was developed and later a Dubbs reforming plant was installed; the polymerization unit is the latest addition.

The Loco Hills Repressuring Association plant in the Loco Hills field of Eddy County, New Mexico, is nearing completion. Contract for construction of the plant was let to Sam Sanders, Artesia, New Mexico, and work was begun the early part of May. Materials needed for construction were obtained with the assistance of the federal government, which owns 80 percent of the acreage. Operation of the plant is expected to begin about October 1.

Construction of a 225-bbl. alkylation unit at a cost of $574,000 has been begun by Standard Oil Company of Ohio at its Cleveland, Ohio, refinery. The National Defense Advisory Commission has issued a certificate of necessity to facilitate construction. It is expected that the new addition will be completed before November 1. The plant will produce 225 bbl. of 100 octane gasoline per day.

Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended August 30, 1941
(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	644	95.7	20,261	24,393
Appalachian	83.8	133	95.7	3,070	1,167
Ind., Ill., Ky.	84.4	637	100.3	14,438	9,469
Okla., Kans., Mo.	80.7	309	92.8	6,672	3,978
Inland Texas	63.2	153	92.2	2,243	1,762
Texas Gulf	91.0	963	96.4	11,148	14,520
Louisiana Gulf	94.2	155	104.7	3,128	3,304
No. La. and Ark.	49.9	51	108.5	378	741
Rocky Mountain	50.1	55	80.9	1,050	554
California	90.9	616	86.2	13,734	77,915
Reported	86.4	3,716	94.7	76,122	137,803
Estimated Unreported		354		5,550	2,600
*EST'D TOTAL U. S. AUG. 30, 1941		4,070		(a)81,672	140,403
*EST'D TOTAL U. S. AUG. 23, 1941		3,975		82,566	138,590
U. S. B. of M. *AUG. 30, 1940		**3,508		84,047	

*Estimated U. S. Bureau of Mines' basis.
**August, 1940, daily average.
(a) Finished 73,746,000 bbl.; unfinished 7,926,000 bbl.

THE Petroleum Engineer

SEPTEMBER, 1941

Mud Analysis as a Basis for Well Logging

Exclusive

☆ Mud logging in West Texas aids operators in determining gas-oil contact zones — Lower gas-oil ratios obtained when casing seat is properly selected

by H. Lee Flood
Associate Editor

IN NEARLY every field in the West Texas-New Mexico area, one of the most difficult problems in drilling and completing oil wells is the accurate determination of data pertaining to the formations comprising the principal oil-producing sections.

Virtually every known method of logging a well has been employed in West Texas in an effort to ascertain formation data more accurately. Although many methods are used to advantage, none has proved quite satisfactory for determining such important information as the gas-oil contact plane or zone, the presence of intermediate waters, and other related data so essential in completing West Texas wells.

One method attracting considerable attention among West Texas operators is that involving analysis of the mud stream for use in constructing a log of the well. The results obtained thus far have been so interesting and have so improved the manner in which many wells have been completed that the method deserves careful consideration.

The method is relatively new. It is only during the last two years that it has been made generally available as a commercial well-logging service. Back of the method currently employed, however, are several years of intensive development work devoted to perfecting the instruments and technique.

Although many operators in oil areas throughout the country know something of the method and have come to refer to the service variously as "trailer logging", "ditch logging", or "mud logging", not many are thoroughly conversant with the principles employed or the manner in which the information is used by the operator.

Principles of Mud Logging

Before coring and electrical logging came into general use, wells drilled with rotary equipment were logged almost entirely by the driller. Besides the evidence disclosed by the cuttings in the mud-returns, other indications such as "rainbows" in the mud pits, gas-cut mud, and threats of blowouts were relied upon as evidence of the presence of oil and gas formations. Deeper wells, modern mud practice, and the development of coring and electrical logging have emphasized the impracticability of these earlier crude methods, the results of which could not be properly evaluated.

The principles of mud logging were developed from the assumption that the drilling mud contains cuttings from the formations through which the bit passes and therefore should disclose valuable information, and that if proper instruments were available oil and gas could be positively detected and measured.

Assume that a well is being drilled with a 10-in. bit at a depth of 5000 ft. at a rate of 10 ft. per hr. and that 800 bbl. of mud is circulated per hour. The volume of the material cut, pulverized, and removed from the hole would be 9425 cu. in., the equivalent of 41 gal., or nearly 1 bbl., per hour, representing

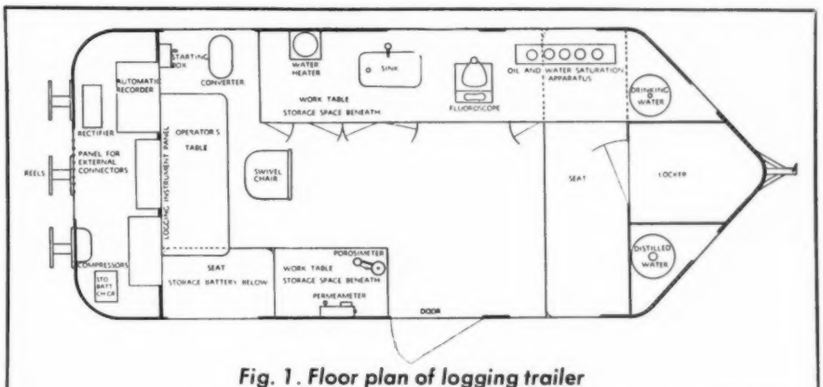


Fig. 1. Floor plan of logging trailer

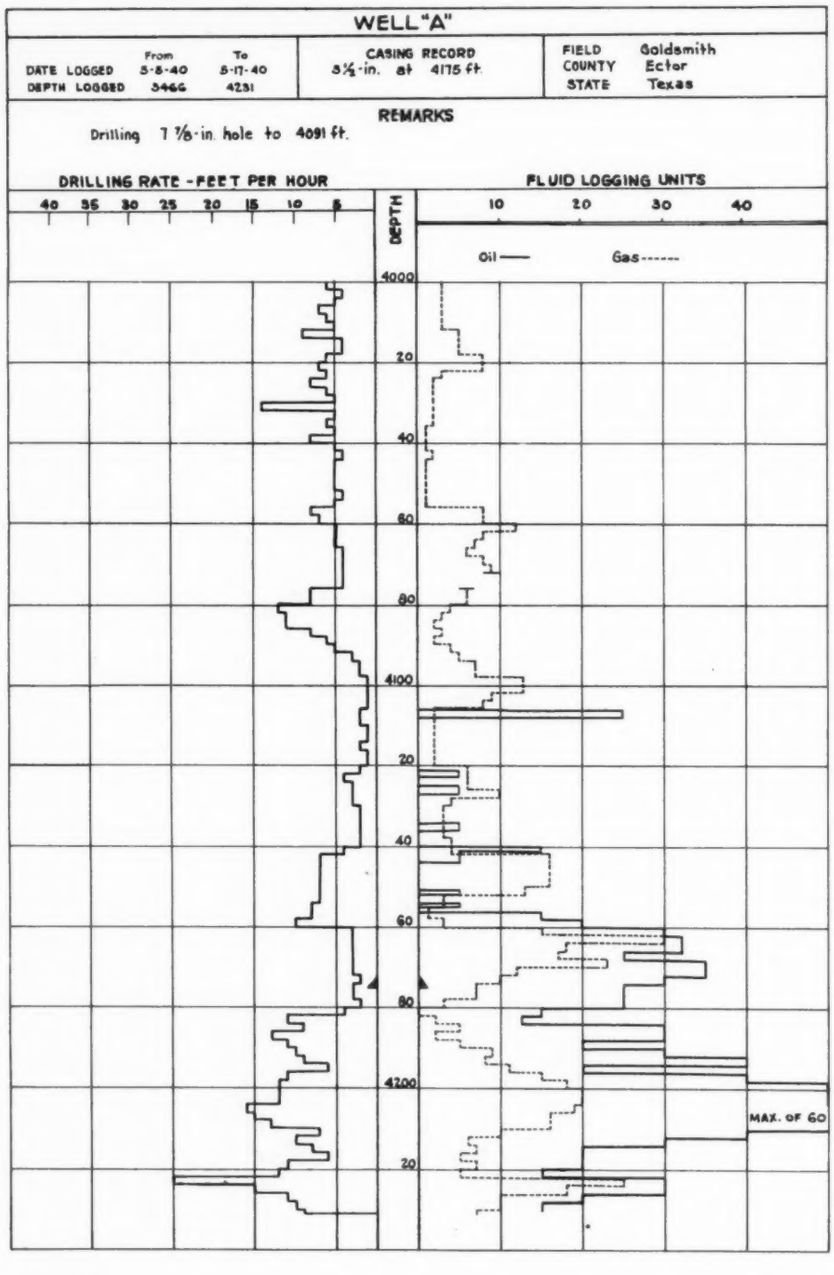
1 part in 800 or 0.125 percent of the fluid circulated. If the porosity of the formation is, say, 30 percent, and the pores are filled with fluid, then approximately one-third of a bbl. per hr. of formation fluid will be added to the circulated fluid — a ratio of approximately 1 part in 2400.

If the pore space were filled with gas at a pressure of, say, 200 atmospheres (3000 lb. per sq. in.), gas from the cuttings would enter the mud at the rate of 330 cu. ft. per hour.

These figures give one an idea of the volume of formation fluids (oil, gas, and water) that are in the mud-returns. Instruments used in mud-logging are sensitive enough to detect even minute quantities of oil or gas; gas volumes as small as one cu. in. per hour can be detected in the drilling mud.

It is important to note that the weight of the mud column prevents the inflow of fluids from the wall of the hole, hence formation fluid (oil, gas, or water) returns is that from the drill cuttings only. Consequently, indications of oil and gas are found only in the mud that is circulated through the bit during the drilling of the formation containing the oil and gas. Should oil and gas enter the hole from that formation after drilling past it, correlation of the oil and gas indications with depth would be useless.

Fig. 2. Log of well low on structure in Goldsmith pool



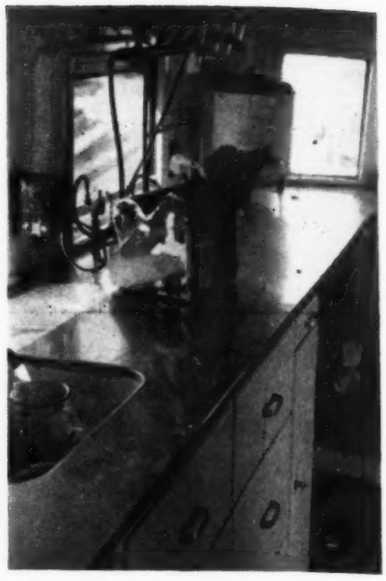


Fig. 3. Samples are viewed in ultra-violet light to detect presence of oil

Details of Mud-Logging Operation

In addition to detecting the presence of oil or gas, it is obviously important to determine accurately the depth at which the indications of oil and gas are observed. This is done by adjusting for the "lag", or the time required for the fluid to reach the surface.

Thus, the mud-logging equipment employed consists of: (1) equipment for the detection and measurement of oil and gas (and also salt water) in the mud returns, and (2) equipment for correlating the showings of oil and gas with the depths.

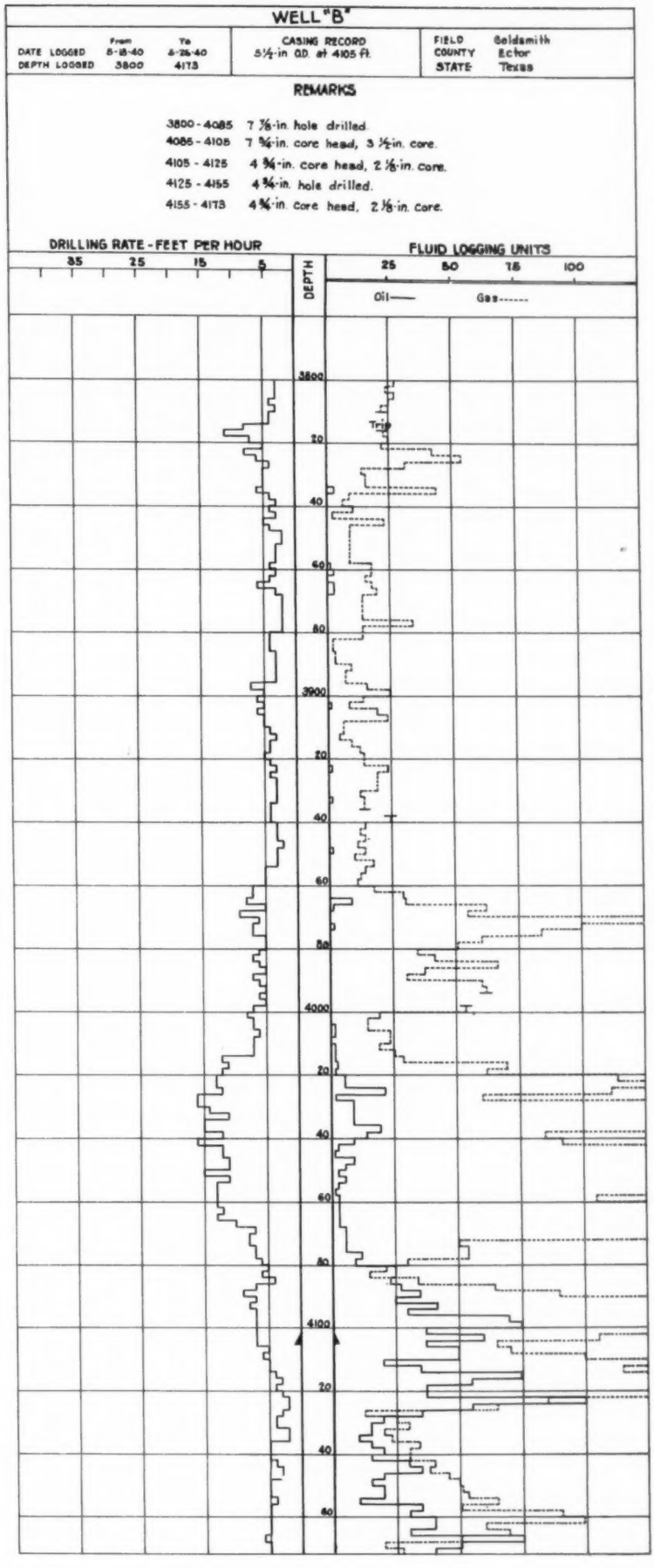
The principal items of equipment are housed in a trailer, the floor plan of which is shown in Fig. 1. All the instruments are electrically operated. Power is obtained from the drilling rig's power plant and provision made for operating on either alternating or direct current.

Detecting Gas and Oil

Indication of the presence and relative volume of gas are observed by means of a "hot wire" gas detector.

As the bit penetrates a gas-bearing formation the mud carries the gas released from the pores of the rock to the surface. In a gas trap set alongside the mud ditch, a portion of the gas is withdrawn from the mud stream and mixed with a constant volume of air drawn into the detector by a vacuum pump, after being filtered, metered, and humidified. The proportion of combustible gas in the mixture is determined by the "hot wire" in the detector and is indicated directly on the instrument

Fig 4. Log of a well high on structure in the Goldsmith pool



panel and recorded on the automatic recording chart.

Oil in the drilling mud is detected by the use of ultraviolet light. The instrument is shown in Fig. 3. Inasmuch as a minute trace of oil will fluoresce in a beam of ultraviolet light, extremely small volumes of oil may be detected. Fortunately, there is a difference in the appearance of fresh crude oil so that there is no difficulty in distinguishing new shows of oil from older ones or from grease or oil with which the mud may be contaminated.

The mud samples used for oil detection are collected by a sampler set over the mud ditch. The paddle wheel is revolved by the velocity of the mud and a small sample of mud is picked up in each revolution. Thus an average sample is obtained for any depth interval.

Recording Mud Circulation Rate

The instruments mounted on the lower central panel of the instrument board shown in Fig. 6 are the pump cycle counters and rate meter. The two counters flanking the central meter count the number of cycles made by the pump and the meter shows the pump rate in complete cycles per minute. The instruments are connected to switches mounted on the pumps.

The pump stroke counter on the right records in step with the counter on the left but is set to maintain a predetermined number of strokes ahead of the left counter, the number of strokes being the pump strokes (and therefore the mud volume) required for a unit volume of mud to circulate from the pump suction to the point at which mud samples are gathered from the mud return pit.

The volumetric capacity of the hole, and from that, the number of strokes to bring a sample to the surface can, of course, be calculated theoretically, but it is much more accurate to measure the number of strokes required for cottonseed hulls or other material fed into the pump suction to reach the shale shaker. Having thus determined the effective displacement of the specific pump, the pump may be used as a mud meter.

Having set the two counters to allow for the "lag", the operation of the instruments is as follows: The operator notes the depth of the well from the depth recorder on the lower left panel, which is, say, 6000 ft. He also notes the reading on the right counter (the one that is reading ahead) and finds it to be 500. This reading is recorded alongside 6000. When the left

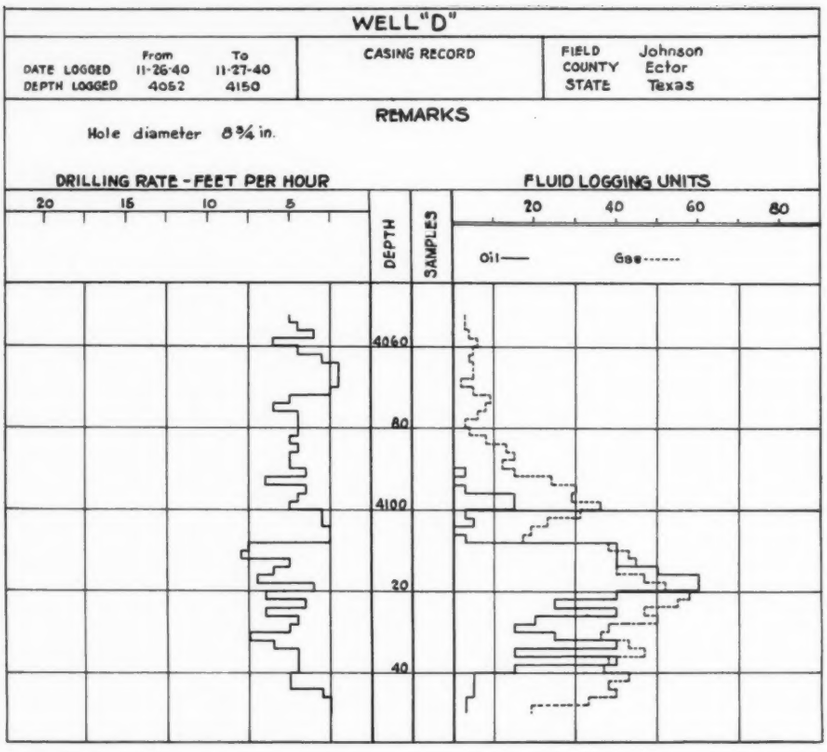


Fig. 5. Log of a well in the Johnson pool

counter registers 500, the operator knows that the mud passing the sampler in the mud trench had passed through the bit as the 6000-ft. depth was being drilled. Let it be assumed that the extension counter reads 1500 when the depth counter reads 6001 ft. All mud collected by the sampler between readings of 500 and 1500 on the main or lagging counter, should then be that carrying the fluid content of the formation drilled between 6000-01 ft.

Depth Meter

The depth meter, which is behind the lower left panel, registers on the two counters, showing depth of the hole and the distance bit is off bottom, respectively. The latter counter registers only when a trip is made or the bit is raised off bottom while circulating.

This instrument is entirely automatic in operation. It has two selsyn motors, one of which is actuated by

Fig. 6. Identification of the various instruments on the operating panel of the trailer

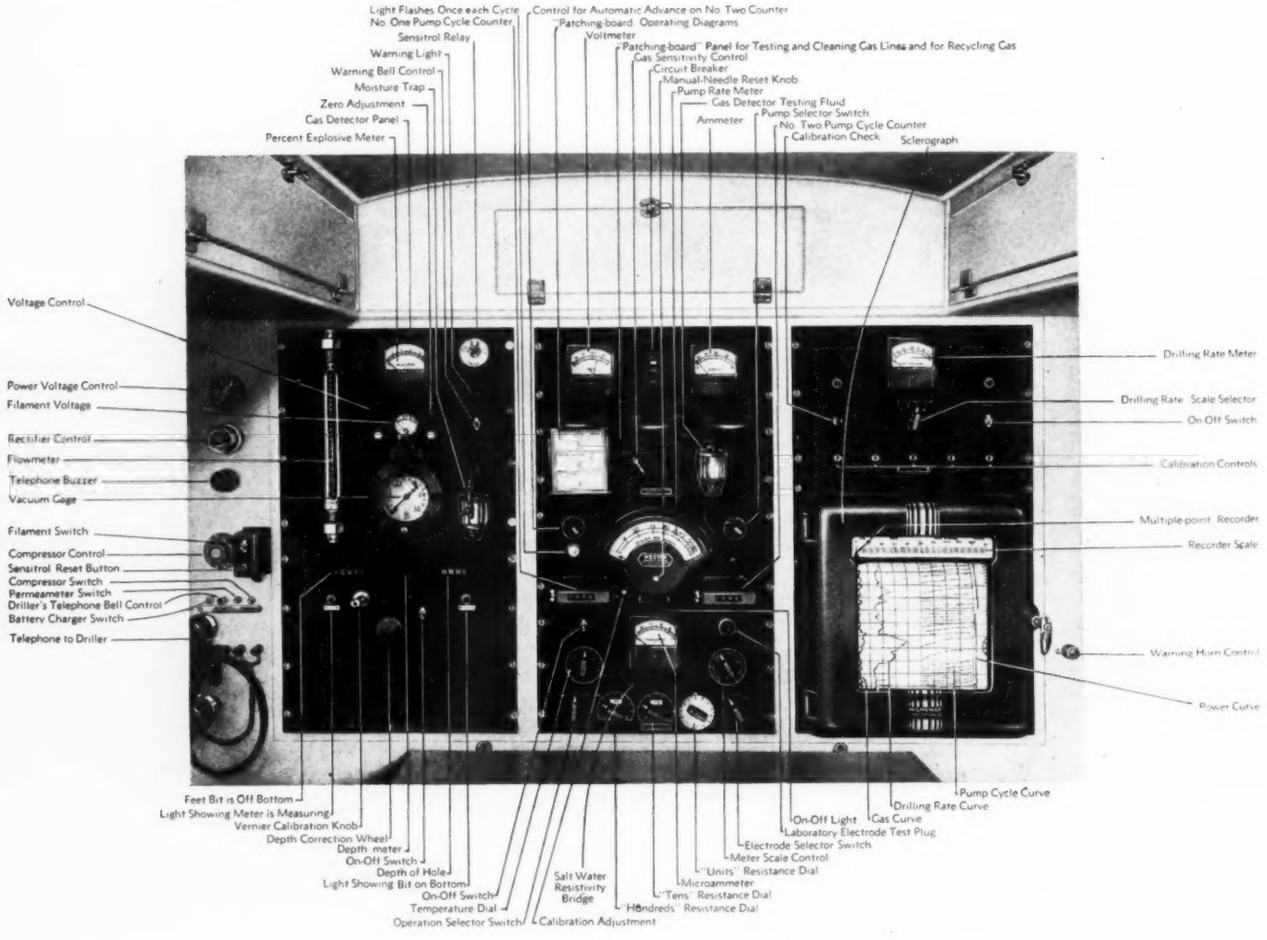


TABLE I

Well	Potential, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Volume of acid, gal.	Volume of shot, qt.	Casing	
					Size, in.	Depth of seat, ft.
A	1034	1076	4,000	..	5½	4175
B	473	1480	..	87	5½	4105
E	921.8	580	10,000	..	7	4963
C	589.9	359	..	540	5½	4354
D	538	521	..	300	7	3977
F	215	..	..	120	..	..

the movement of the traveling block in the rig. Movement of this motor energizes a companion motor behind the instrument panel. Downward movement of the bit increases the reading of the depth meter. When the movement of the bit is upward the depth meter remains stationary and the counter showing the distance off bottom begins operating.

Although the primary purpose of the depth meter is to apprise the logging operator of drilling progress, it serves as a check against the driller's tally of depth. It also shows the rate of penetration by recording in ft. per hour the time required to drill the formations.

Representative West Texas Drilling Logs

A few of the more interesting logs of West Texas wells have been selected to illustrate the manner in which this logging information may be employed.

Logs of wells "A" and "B", shown in Figs. 2 and 4, respectively, may be compared, for both wells were drilled by the same company in the Goldsmith pool. Well "A" was drilled low on the structure, but well "B" was drilled high on the structure. Well "B" shows a definite gas cap, whereas Well "A", being on the flank, does not indicate a predominant gas cap above the oil-producing zone. It will be noted that in both wells the casing strings were set several feet below the gas-oil contact zones in order to allow for an expanding gas cap.

The areas under the oil and gas curves are indicative of the relative productivity of oil and gas. The fluid logging units used in plotting these curves are obtained by multiplying the instrument readings by factors that reflect the rate of drilling and the diameter of the hole.

The potential of well "A" was 1034 bbl. per day and the gas-oil ratio 1076 cu. ft. per bbl. The potential of well "B" was 473 bbl. per day and the gas-oil ratio 1480 cu. ft. per bbl. These potentials substantiate the predictions made from a study of the logs.

Well "C", the log of which was not available, is in the extension of the North Cowden field. The log obtained from mud analysis was used as a guide in coring on this well and led to a reduction in the number of cores taken. The method used to determine the need for cores was to suspend drilling when softer formations were encountered. Three or four feet of formation would be penetrated to allow time for the return of the mud to the surface. If the oil or gas shows indicated by mud analysis appeared to be of commercial importance, a core was taken.

Examination of the log reveals that only two sections had important oil saturation. As can be seen from the log, saturation in the upper sections of the hole, though slight, was enough to encourage the operator to keep coring.

The log of well "D", shown in Fig. 5, was employed principally for determining the most advantageous depth to place the charge in shooting the well. This well is in the Johnson pool. As the cuttings from this well were not satisfactory the operator would have been at a loss to know where to place the charge. The log also enabled the operator to determine the proper casing seat and the quantity of explosive to use.

The log of well "E", shown in Fig. 7, indicates clearly the formations containing oil and gas and their rela-

Fig. 7. Log of a well in the Slaughter field

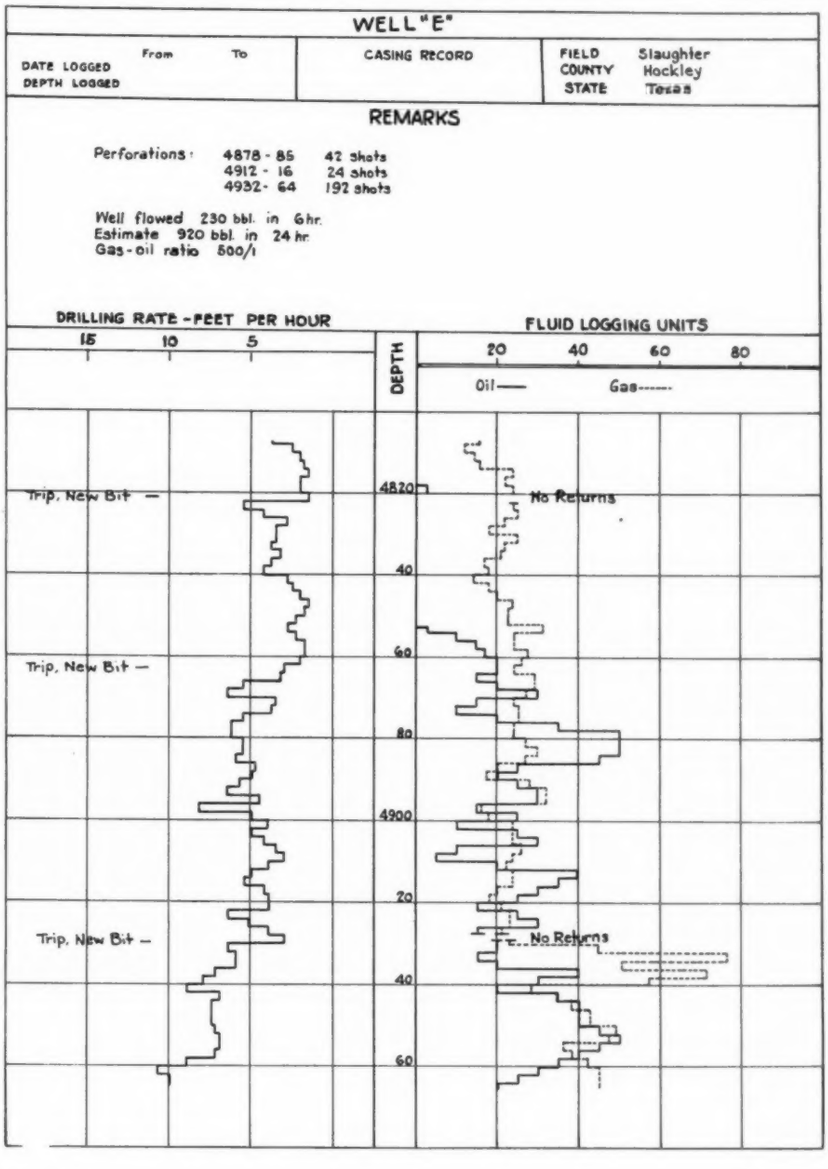
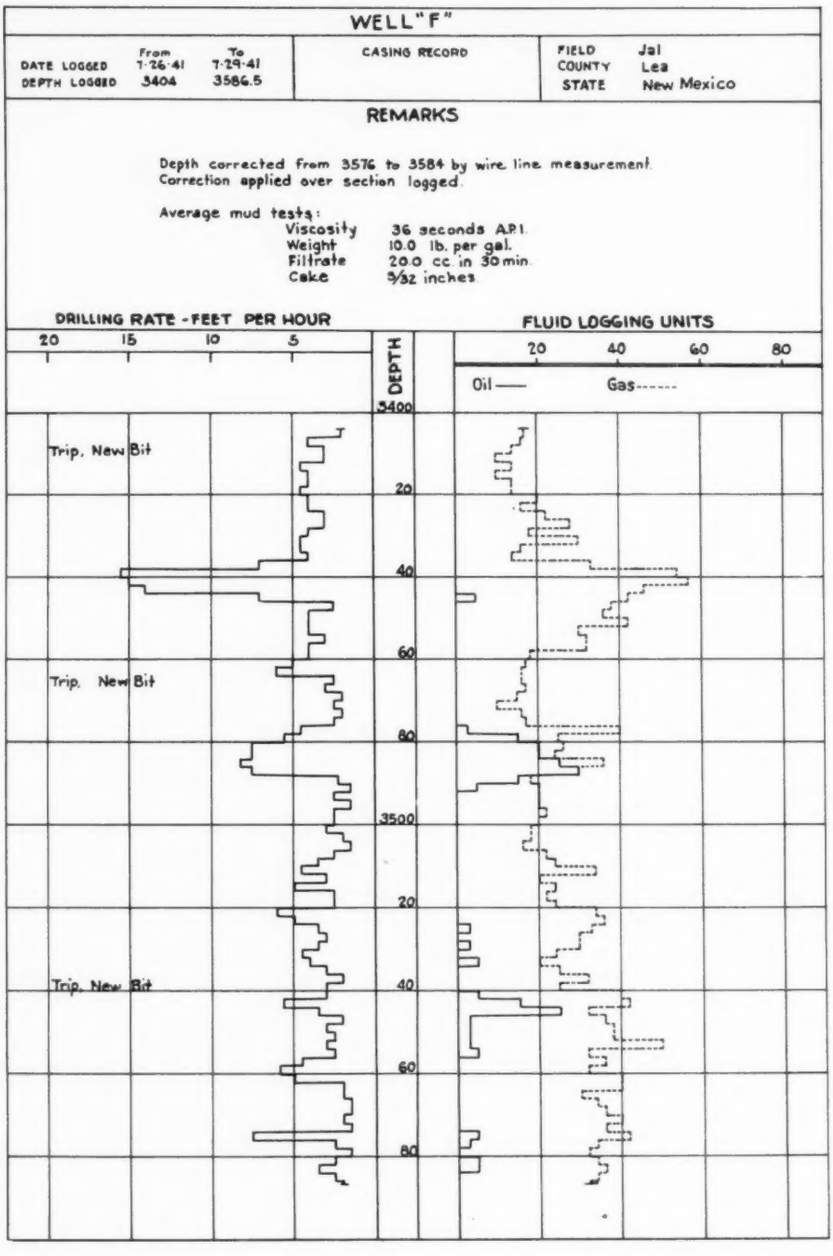


TABLE 2
Data on North Cowden Wells

Well	Potential, bbl. per day	Total area under oil curve on log, sq. in.	Gas-oil ratio, cu. ft. per bbl.	Volume of acid, gal.	Volume of shot, qt.	Casing	
						Size, in.	Depth of seat, ft.
1	1044	7.43	762	..	380	5½	4027
2	1169	6.94	713	..	415	5½	4012
3	849	6.27	752	..	320	5½	4041
4	589.9	2.34	359	..	540	5½	4354
5	306.1	1.93	451	..	518	5½	4288
6	153	0.6	394	..	325	5½	4400
7	482	2.00	583	..	245	5½	4321

tive volumes. The log of this well in the Slaughter area was used to good advantage; the casing was run to total depth and gun-perforated opposite the sections showing the best oil saturation. If at any time in the future the operator desires more gas, it can be obtained by perforating a section having a high gas content as shown by the gas curve.

Fig. 8. Log of a well in the Jal, New Mexico, field



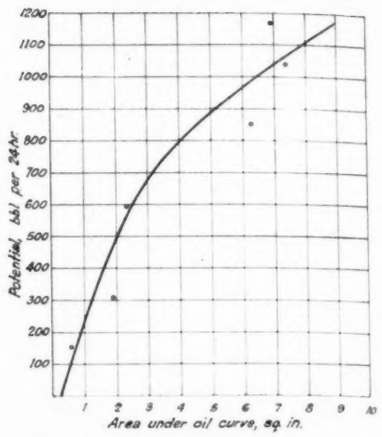


Fig. 9. Correlation of areas under oil curve with well potentials

Well "F", in the Jal field, New Mexico, the log of which is shown in Fig. 8, is an example of a well in a field where a high-pressure gas sand lies above the oil-producing formation but is separate and distinct. The operator wanted to be certain that this gas zone was completely cased-off in order to obtain a satisfactory gas-oil ratio.

Estimating Potentials

Although it is not to be considered as a definite part of mud-logging service, it is interesting to note the accuracy with which the area under the oil curve on the log may be correlated with the potential of the well. Thus far, attempts to develop such a correlation have been confined to wells logged in the North Cowden field.

Data used in constructing the curve in Fig. 9 are shown in Table 2.

As additional wells in the North Cowden field have been logged, remarkably close predictions of the potential have been made from a study of the total area under the oil curve.

At the present time, it is impossible to translate such data in one area in terms of what might be expected in another area. Accurate prediction of potential within a specific area such as North Cowden depends, too, on the method of well completion. If the prediction is based on the total area under the oil curve, and only the largest single formation is treated and produced, then obviously the prediction should not be expected to be valid.

This interesting development suggests the possibility that when hundreds or even thousands of such correlations are made in wells all over the country a reasonably close pattern may be developed that may permit potentials to be estimated, even on wildcats on which the mud-logging service is employed.

General view of Skelly Oil Company's Cunningham gasoline plant

Gasoline Plant Employs Two Fractionators in Series

PETROLEUM ENGINEER Exclusive Feature

☆ High-pressure absorption oil pumped to low-pressure system eliminates one set of fat oil pumps and recompressor

by J. C. Albright

WHEN producing two grades of natural gasoline in many plants, the plan of batch processing is followed if only one column is installed, but to produce two grades continuously as the commodity leaves the still condensers, two columns are required.

To produce definite grades of gasoline, each having a predetermined composition, a gasoline plant near Cunningham, Kansas, is equipped with two columns, each having its full complement of pumps, exchangers, and condensers. Raw natural gasoline is pumped in a continuous, unbroken stream to the first column from which stabilized gasoline is taken from the base, and raw L.P.G. (liquefied petroleum gases) from the condensed overhead stream. The second column receives the raw overhead from the first, definite R.V.P. (Reid vapor pressure) "butane" is recovered from the base, and lower boiling fractions not necessary to the finished product are removed from the overhead.

Basically, this gasoline plant operates on two separate absorbing pressures. Low-pressure gas from older oil wells is collected in a gathering system that delivers the commodity to absorbers operating at approximately 50 lb. per sq. in. gauge pressure with the residue boosted to higher pressures for pressure maintenance of the producing formation. The second set of absorbers operates at a pressure of approximately 600 lb. per sq. in. gauge, on gas from newer wells that can be operated successfully at higher trap pressures. This gas, after leaving the absorbers, is dried with diethylene glycol to a dewpoint of 15° F. for distribution to distant points as industrial and domestic fuel.

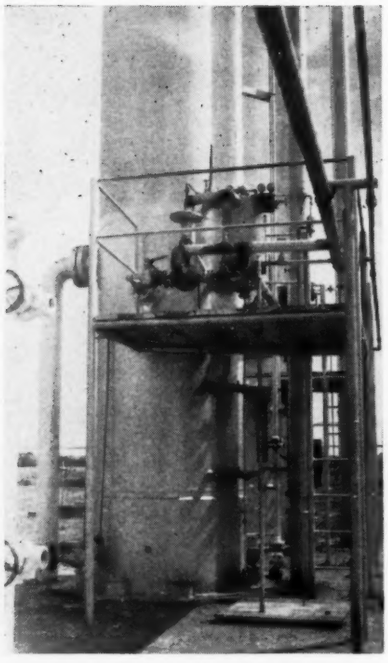
J. C. ALBRIGHT

was drilling superintendent for H. J. von Hagen in North Texas area, 1919-1921—With the Noble Oil and Gas Company, Burkburnett, Texas, from 1921 to 1923—Joined staff of the Dixie Gasoline Company in 1923 and became Texas manager—Employed by Phillips Petroleum Company in 1925 and was sent to New Mexico, where the company constructed a natural gasoline plant—Left Phillips in 1929 and for a time operated as a consulting engineer—For last 12 years has devoted virtually all his time to free-lance writing for trade journals.

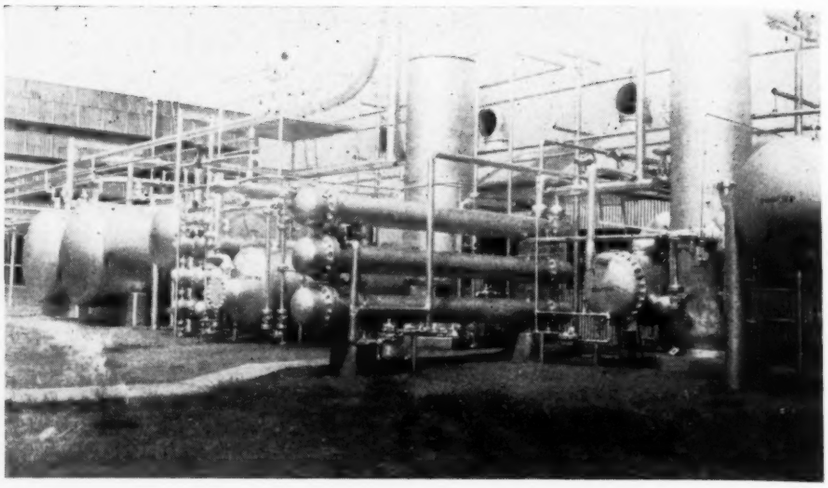
High-Pressure Absorbers

Two high-pressure absorbers, 66 in. by 47 ft. are employed in parallel operation. These absorbers have scrubbers built into the base to eliminate contamination of the absorption medium by crude oil that might pass through field separators and pipe-line drips. These absorbers are operated with an absorption oil-to-gas ratio of about 6 gal. per M. cu. ft. of gas processed. Oil entering the absorbers and flowing from the bottom section is controlled by instruments and float mechanism.

As only one distillation system is



Control equipment on diethylene glycol contactors



Exchangers and reboilers

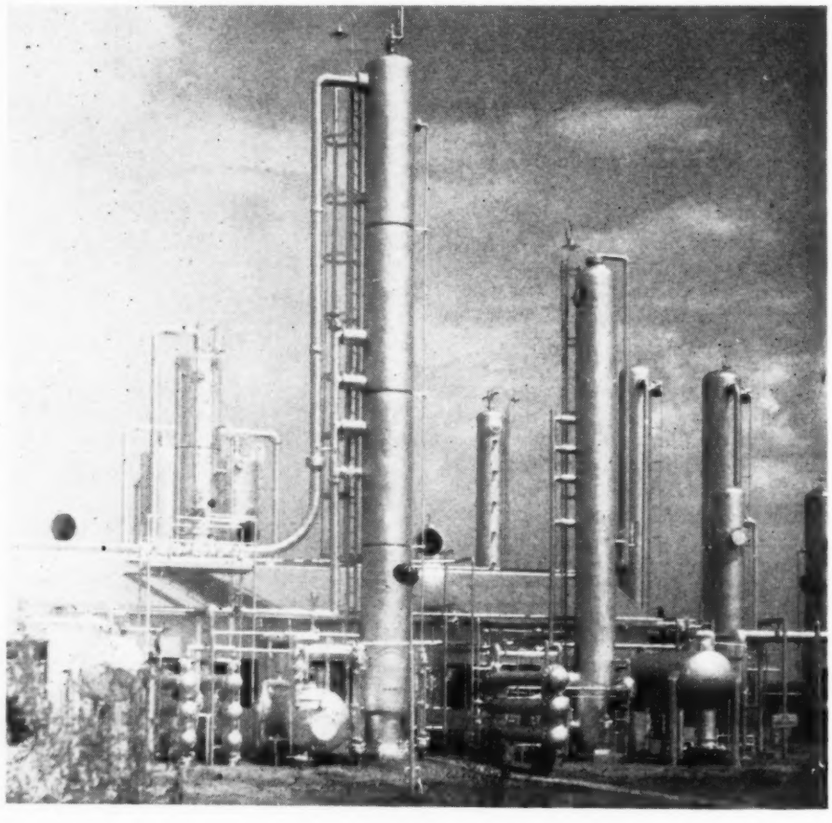
used in this plant, the high-pressure oil is pumped from the absorbers directly into one of the low-pressure absorbing columns. Two reasons are given for this method of operation. The first is, that by blending the absorption oil in a common stream, only one set of fat-oil pumps is required. The second reason is, that by pumping the high-pressure oil into one of the low-pressure columns, the fat oil is relieved of the dissolved ethane and other low boiling fractions that are not required for natural gasoline or L.P.G. By venting the high-pressure oil into one of the low-pressure absorbers, fractions liberated from the fat oil are reabsorbed and prevented from being carried away with the undesirables, and also takes the place of a recompressor engine to handle vapors from fat-oil vent tanks.

Finished Products

The raw gasoline from the distillation system is produced with a R.V.P. of 55 to 60 lb. It is then pumped to a 36-in. by 45-ft. 6-in. column with a 10 by 6 by 12 simplex steam-driven close-clearance pump at a rate of approximately 1200 gal. per hr. When producing a 12-lb. R.V.P. natural gasoline from the base of this fractionator, the column is operated at 175 lb. gauge pressure, and the reboiler maintained at a temperature of 304° to 306° F. The top temperature is held to a constant temperature of 160° F. with reflux pumped back at a ratio of 4:1. Stabilized gasoline flows by column pressure through exchangers and coolers to storage for shipment to points of utilization.

The overhead vapors leaving this fractionator are condensed and received in an accumulator from which excess above reflux requirements is pumped to the L.P.G. fractionator. A 10 by 5 by 12 simplex close-clearance pump is employed to pump this condensate to the L.P.G. fractionator, which is operated at a column pressure of 200 lb. when producing an L.P.G. having a R.V.P. of 80 lb. To make this product, the reboiler is maintained at a temperature of 280° F., and the column top is held at a temperature of 120° F. with overhead condensate pumped back at a ratio of 4:1. Excess overhead is vented from this 32-in. by 30-ft. column into the repressuring system for use in the field.

Fractionators in which low R.V.P. gasoline and L.P.G. are manufactured



Mechanical chart calculator discloses volume of fluid metered in one operation

by

H. Lee Flood

Associate Editor

Simplifying Orifice Meter Chart Calculations

☆ Percentage approach is more readily grasped by chart readers—New mechanical calculator gives direct reading of fluid volume in one operation

FOR years, the orifice meter, or differential pressure recorder as it is often called, has been almost universally accepted and used as the instrument whereby gas volumes are measured in the field and on pipe lines.

More often in the past than now, orifice meters were purchased and installed and their records used as a basis of measurement with little concern for accuracy except to conduct a perfunctory calibration test as the instrument was placed in operation.

In recent years, increased attention has been given to the details of orifice meter measurement so that generally a decided improvement in measurement accuracy has resulted. Gas measurement short courses, conducted each Spring in various parts of the country, have contributed immeasurably to the knowledge of meter men and others interested in gas measurement.

Aside from the sources of inaccuracy that must be watched in the field, such as calibration of the meter itself, inspection of the plates and careful measurement of the orifices in the plates, using a micrometer, and routine or periodic measurements of flowing temperatures and gravities, there is one possibility for error that has received close study by some but in many instances is not given the attention it deserves. This is in the calculation or reading of the orifice meter charts and it is to this phase of gas measurement that the present discussion is devoted.

Orifice meter chart calculation is usually performed by girls (or boys) in the gas accounting department. So far as is known, no business school or high school has ever introduced a course in chart calculation for the purpose of training students for this work. It is necessary for a company, therefore, to train its own chart readers. Usually, a new employee in the gas accounting department begins as a chart reader. When a chart reader resigns or is promoted, his or her place is filled by a "green" hand who knows nothing about the work.

Unfortunately, too often the newly employed chart reader is given only a brief and not too clear explanation of the manner in which an orifice meter operates and of why it measures gas flow. The stock explanation concerning static pressures—gauge and ab-

Mechanical calculator in use

solute—and differentials, together with a reading assignment in a handbook on gas flow, usually leaves the new employee confused. Gradually he or she may become adept in performing the mechanical operations, but often a clear understanding never is attained.

The Percentage Approach

One method of inducting new chart readers into the company and acquainting them with the work they are to do is to give them a simple explanation of percentages. This method has been developed by the head of gas accounting work for one of the more important gas producing companies in the Texas Panhandle and is based on years of experience in working with new chart readers.

The manner of presenting the percentage approach makes it easy for a new employee to grasp the essential features readily. Pressure and differential as such are forgotten and the student is asked to consider the pressure scale lines merely as colored lines on the chart. It is then pointed out that there is no essential difference between these scale divisions and the markings on a tape measure or a common ruler.

The scale lines represent percentages of the distance between the zero and 100 percent lines on the chart. In the case of a square root chart, the figures represent percentages expressed in the square roots thereof, so it is only necessary to put down what is seen. These two percentage figures for one hour multiplied together gives an extension, or a percentage of the maximum chart load for one hour, the maximum chart load being the quantity of gas that the chart would represent if both pressure and differential lines were on the 100-percent line of the chart.

These extensions are made for each hour; the reason for adding the hourly extensions to arrive at a total extension is because an hourly coefficient is used. A coefficient may be based on any unit of time or on any pressure and differential range.

If the differential and pressure were constant (did not vary) during the entire time represented on the chart, then one reading would give the proper percentage of the maximum chart load. The total extension, however, as now arrived at, divided by the hours in the chart period, divided by 100, would result in a proper percentage to be applied to the maximum chart load.

In reading square root charts, all readings are in percents, rather than in lb. per sq. in. static pressure and inches of water differential pressure. The coefficients used in connection with these charts are based, therefore, on 1 percent pressure and 1 percent differential. If a certain volume of gas will pass the meter at 1 percent, then at 25 percent, 25 times as much gas will pass. It is just simple arithmetic—there is no mystery about it.

Calculating Charts Mechanically

If it were possible to arrive at the percentage of the maximum chart load mechanically there would no longer be a need for an hourly coefficient and maximum chart loads would be recorded instead.

Inasmuch as the total extension of a square root chart as now used, divided by the hours of the chart period, divided by 100 and multiplied by the maximum load chart equals the value derived by multiplying the hourly coefficient by the total extension, then the proper percentage of the maximum chart load is the average of the various products of the square roots of the differential and the static pressures.

Various mechanical methods of chart calculation employing either planimeters or integrators have been in use for a number of years. These methods have offered a more precise method of determining the exact product of the two readings—the static and differential—and then by resorting to a subsidiary calculation, involving the coefficient for the specific meter and plate with which the chart was used, the volume of gas can be determined.

Based on the conception of coefficients and meter readings as percentages, a chart calculator has been perfected that not only determines the proper percentage of the maximum chart load that is represented on the chart but it permits the introduction of the coefficient in the calculation so that the quantity of gas or other fluid measured by the orifice meter may be determined immediately.

The design of the machine and the details of its operation, in view of the time saved in its use should be of in-

terest to all who are concerned with gas accounting procedures.

Principles of the Calculator

The percentage method in chart calculation is not new, inasmuch as it is actually used in calculations from records on square root charts.

The new machine calculates the correct percentage of maximum chart capacity, coefficients being based on 100 percent differential, 100 percent static pressure, and the total chart period, thus representing the maximum quantity measured by the chart. Hourly coefficients are for calculation of charts by the inspection method, because it is customary under that method to make hourly calculations. The machine makes the calculation for the whole chart period; but the quantity of gas for any period within the chart period may be ascertained by merely stopping the machine and reading the counter. If a coefficient is changed within the chart period, it is only necessary to stop the machine at the expiration of the old coefficient, put in the new coefficient, and continue to the end of the chart period.

Design

In developing the machine the first need was a means of multiplying one percentage by another, and of moving the counter assembly out on the chart a distance represented by the product of these percentages. This was accomplished by using a simple lever with a variable fulcrum or rather a lever whose pivot is attached to a shiftable carriage. Next, it was necessary to develop a means of operating this lever both longitudinally and pivotally. This was accomplished by means of auxiliary sliding carriages working at right angles to the movement of the main carriage to which the multiplying lever is attached. Then it was necessary to design a means of imparting to the auxiliary carriages, movements equal to the square roots of the percentages of travel of tracing styli across the face of the chart. If the calculating mechanism of the machine is to reflect the square roots of percentages of travel of the tracing styli across the chart face, then the movements of the tracing styli must be the squares of the percentages of movements of their respective portions of the calculating mechanism. To accomplish this, cams were laid out on the squares of the percentages of movements of the differential and pressure cross slides. Actually the patterns for the cams were accurately laid off through the operation of the machine itself. After these cams were cut, they were checked to 0.001 in. By connecting these cams to stylus-carrying blocks the square roots of the percentages of travel by the styli were imparted to the machine calculating mechanism.

As the stylus-carrying blocks move on a straight line, the styli follow time arcs. A means was needed to straighten this time arc mechanically, so that movement of the stylus on the time arc would be identical to the movement of the stylus-carrying block on a straight line. This was accomplished by means of a curved guide on which the stylus moves away from the block.

Next it was necessary to perfect a means of introducing the coefficient. This was done by means of a variable angle bar that governs the longitudinal movement of the multiplying lever. Through the operation of this bar, longitudinal movement of the multiplying lever can be graduated to 1/100,000 (one one-hundred-thousandth) of its maximum movement, the maximum movement being 4½ in. There is a means of quickly adjusting the position of this variable angle bar. All coefficients are treated as percentages—a coefficient of 5, 50, 500, or 5000 being treated as fifty (50) percent. Coefficients to be used with the machine are the maximum chart capacities multiplied by the machine factor. These coefficients are as easy to calculate and set up in record form as any other coefficient.

In order to facilitate the following of chart lines with machine styli, pinions operated by hand wheels were attached to the machine handles. These pinions engage racks, and make it possible to follow accurately small fluctuations in differential and pressure.

It is important that there be no lost motion in the machine. The machine, therefore, has been fitted with numerous ball bearings, and important pivot pins have been set in needle bearings.

The counter is similar to that of a planimeter, but to facilitate reading, it is equipped with a magnifying mirror. The characters are so arranged that they may be accurately read in the mirror.

There is a means of adjusting the relationship of the cam bearing with the stylus point. This adjustment is necesary, to add atmospheric pressure to obtain absolute pressure when only gauge pressure is shown on the chart.

Front sections of the machine are made for charts with different time arcs. Fronts are removable and can be exchanged when a change in curvature of a time arc occurs. This change can be made in approximately one minute. These fronts consist of time arc plates and styli assemblies.

It has been found that charts sometime stick to the chart table when a vacuum has been created, and to avoid lost time from this cause, finger holes have been provided in the table to facilitate removal of the chart.

The chart table revolves electrically and is controlled by a rheostat operated by the foot.

Operation

Differential and pressure lines are followed on the chart with the styli by the operator. As the chart table revolves, the counter wheel moves out from the center of the chart a distance equal to the product of the square root of the percentages represented by these lines multiplied by the percentage factor representing the coefficient. On completion of the chart run, the quantity of gas is read on the counter in M. cu. ft., the pressure base being included in the coefficient.

Assuming the hourly coefficient of a square root 24-hr. chart to be 2.0000, the coefficient for this chart for machine use would be:

2.0000 × 24 (hours) × 100 (hourly maximum extension) × 1.28 (machine factor = .6144.

or

2400 (maximum extension) × 1.28 (machine factor) = 3072 (corrected maximum extension;

3072 × 2.0000 (hourly coefficient) = 6144. (machine coefficient for the chart).

Assuming a differential of 25 per-

TABLE I

Date	No. of charts	Total extension by inspection method	Total extension by machine	Percent of machine calculations to inspection calculations
Sept. 1, 1941	50	62,894.01	62,895	100.00
Sept. 2,	52	50,716.56	50,726	100.02
Sept. 3,	57	50,190.40	50,165	99.95
Sept. 4,	58	52,867.69	52,618	99.53
Sept. 5,	54	48,736.94	48,657	99.84
Sept. 6,	54	50,096.63	50,059	99.92
Sept. 7,	51	48,556.65	48,471	99.82
Sept. 8,	52	50,884.23	50,817	99.87
Sept. 9,	53	52,111.53	52,055	99.89
Sept. 10,	53	50,783.67	50,714	99.86
Totals	544	517,838.31	517,177	99.87

cent and an absolute pressure of 49 percent, the percentage of the maximum quantity would be $0.25 \times 0.49 = 0.50 \times 0.70 = 0.35$ or 35 percent. The maximum quantity of the chart is 4800 M. cu. ft. Multiplying 4800 by 35 percent, the volume measured is 1,680,000 cu. ft. Inasmuch as the machine factor is 1.28, this factor should be applied to the maximum quantity: $4800 \times 1.28 = 6144 =$ machine coefficient.

If the machine coefficient bar is moved to 6144, and the 5 and 7 lines on a square root chart are followed with the machine styli for the full chart period as the chart revolves on the chart table, the answer will be 1,680,000 cu. ft.

To convert hourly coefficients to coefficients for machine use, the procedure is as follows, assuming a machine factor of 1.28:

Square root charts:

Hourly coefficient $\times$ 3072

Regular charts: (for meter having a 50-in. differential and a 500-lb. spring):

$$\frac{500 \times 50}{100 \times 100} \times 3072 \times \text{hourly coefficient}$$

(for meter having a 50-in. differential and a 1000-lb. spring):

$$\frac{1000 \times 50}{100 \times 100} \times 3072 \times \text{hourly coefficient}$$

In other words, the square root of the product of the pressure and differential ranges divided by the square root of 10,000 equals a factor to be applied to an hourly coefficient to convert it for use in connection with a square root chart.

In the event the machine is to be used, coefficients would be converted as set out above.

Gas accountants would enter these coefficients on the charts and pass them to the machine operator.

The machine operator places chart on machine chart table, moves coefficient bar to proper setting, notes reading on measuring wheel, runs the chart, notes reading on completion of run, and subtracts initial reading from final reading. The difference in these two readings is the quantity or volume of gas or other fluid measured.

The machine makes an instantaneous and continuous calculation for the duration of the period the chart has been on the meter gauge, such calculation being, of course:

$$C = \sqrt{hp}$$

in which:

C = coefficient

h = differential, in. water

p = absolute pressure, lb. per sq. in.

All of the above factors are expressed in percentages.

Accuracy

A ten-day test, on charts with differential and pressure lines in every conceivable position on the chart face, showed the volume from machine calculations to be 99.87 percent of the volume calculated by the inspection method. The inspection chart calculators read these charts as closely as possible before they were run on the machine. On rough charts, inspection figures should be higher than figures arrived at with an instrument. An inspection reader, averaging 60 percent and 80 percent over an hour would probably read it as 70 percent. The correct reading would be 69.28 percent.

The data in Table 1 show the results of comparative tests of inspection versus machine accuracy. The chart runs on the machine were made by office girls who had had no previous experience with an instrument of this type.

The writer is indebted to W. F. Martin, Texoma Natural Gas Company, Amarillo, Texas, for the ideas and material presented in this article.

P 437.

Running 7-in. Casing in 7⅞-in. Hole

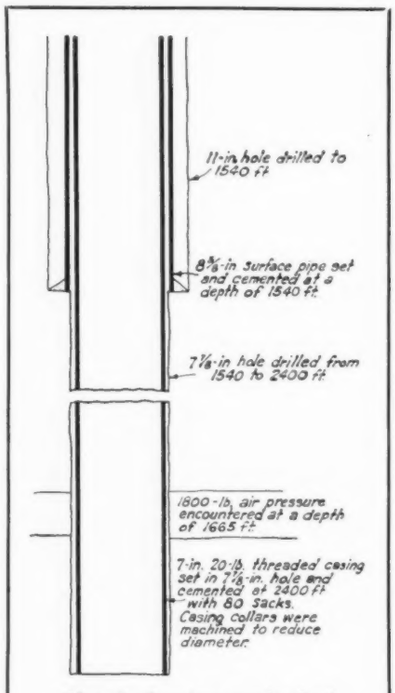
THIS account might easily be classed as a "believe it or not" item but it does indicate what oil-well drillers can do when faced with an emergency.

Many would say it is physically impossible to run 7-in. casing in a 7⅞-in. hole but this feat was actually performed recently during the course of drilling an oil well in the Sand Hills area of West Texas.

The surface hole had been drilled with an 11-in. bit and 1540 ft. of 8⅝-in. casing had been set and cemented as a surface string.

In drilling ahead below the surface casing, 7⅞-in. hole was dug. An unexpected "air" pocket under 1800-lb. pressure was encountered at a depth of 1665 ft. In nearly all fields in the West Texas area, one of the headaches of drilling is the high-pressure air (or gas) present in the Yates sand.

The mud was weighted and the well was deepened to a depth of 2400 ft. without difficulty. Anticipating the difficulty of controlling both the air and the gas expected just below 2400 ft. it was essential that the air be disposed of before proceeding.


11-in. hole drilled to 1540 ft.
8⅝-in. surface pipe set and cemented at a depth of 1540 ft.
7⅞-in. hole drilled from 1540 to 2400 ft.
1800-lb. air pressure encountered at a depth of 1665 ft.
7-in. 20-lb. threaded casing set in 7⅞-in. hole and cemented at 2400 ft. with 80 sacks. Casing collars were machined to reduce diameter.

Sketch showing method of running casing

Accordingly, an attempt was made to squeeze the formation producing the air using a cement retainer attached to the drill pipe, the latter serving as the conductor string for pumping the cement in the well.

Failing in the attempt to shut-off by squeezing, it was then decided to try running 7-in., 20-lb. casing in the hole. Inasmuch as the outside diameter of a 7-in. casing collar is 7¾-in., obviously it was necessary to machine the collars to reduce the diameter. As much of a cut as could safely be made without impairing the threads was taken on each collar.

The hole was filled with 11-lb. mud as the casing was run in the well, aiding in lubricating the pipe. The bottom of the casing was equipped with only an open shoe.

As the last length of casing was made-up, the line from the mud pumps was hooked-up so that mud could be circulated prior to cementing the string (with 80 sacks). The fact that 800-lb. pump pressure was sufficient to hold the pipe up indicates the extremely close passage between the pipe and the hole.

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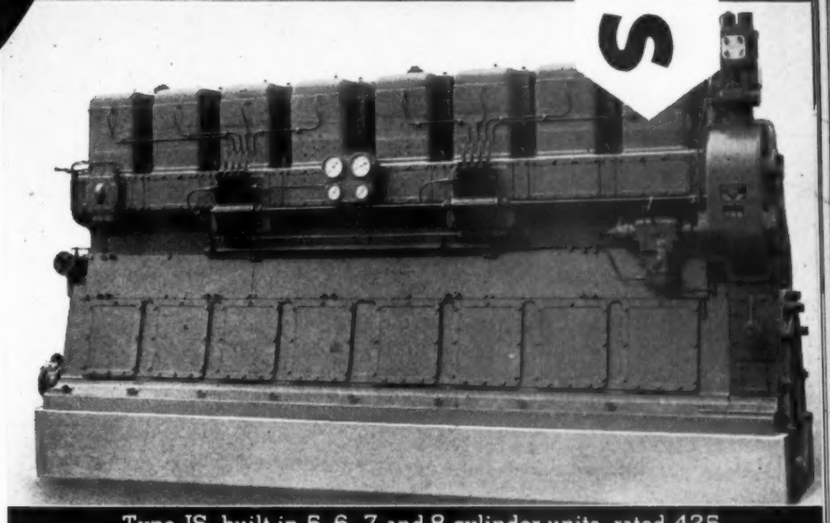
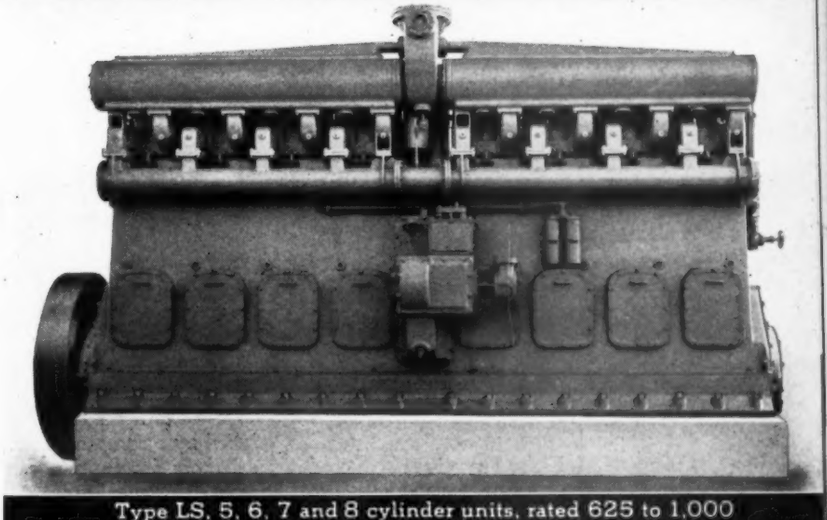


Type JS, built in 5, 6, 7 and 8 cylinder units, rated 425 to 675 hp for pipeline pumping.



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A Critical Analysis of the Application of the Back-Pressure Method in Studies of Gas Reserves

PETROLEUM ENGINEER Exclusive Feature

☆ A comparison is made of various ways of treating composite data from a group of wells

PART 1

by J. William Ferguson, Assistant Gas Engineer,
Canadian River Gas Company

THE purpose of this article is to point out some of the things that can be done legitimately with back-pressure curves of natural gas wells, and, conversely, some operations advocated by others, but which are mathematically unsound. A lack of proper respect for the peculiarities of behavior of logarithmic graphs has led to the advancing of a number of misapplications of the back-pressure curves.

A brief review of the mathematical principles underlying the use of straight lines on log-log graph paper may be helpful.

If the horizontal scale is called "x" and the vertical "y," the distances measured in either direction are proportional to the logarithms instead of the actual values of x and y. A straight line on log-log paper may be represented by an equation of either of the following forms:

$$\log y = m \log x + \log b \quad . \quad (1)$$

$$\text{or } \log x = n \log y + \log c \quad . \quad (2)$$

Equations (1) and (2) may be rewritten, respectively, as:

$$y = b\,x^m \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$\text{and } x = c\,y^n \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The forms (2) and (4) are those commonly employed in back-pressure tests. The value "c" is called the "coefficient," and the value "n" is called the "exponent," or the "slope" of the curve.

Now, let us consider two straight lines whose equations have been written in the form (4):

$$x_1 = c_1\,y^{n_1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$x_2 = c_2\,y^{n_2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

If the values of n_1 and n_2 are identical, as in Curves A and B of Fig. 1, the two equations may be added, to give a new equation:

$$X = x_1 + x_2 = (c_1 + c_2)\,y^n \quad . \quad (7)$$

which represents another straight line on logarithmic paper, as shown by Curve C, which has the same slope as the original curves, and is such that the value of X for any given value of Y will be the sum of the values of x_1 and x_2 for the same value of y, and has its equation in logarithmic form:

$$\log X = \log (c_1 + c_2) + n \log y \quad (8)$$

If, on the other hand, the values of n_1 and n_2 are not identical, as in Curves A and D of Fig. 1, such addition as we performed before results in the equation:

$$X = x_1 + x_2 = c_1\,y^{n_1} + c_2\,y^{n_2} \quad . \quad (9)$$

It is readily seen that it is impossible to write this in a logarithmic form corresponding to equation (8). The graphic significance of this fact is that the plotting of equation (9) on log-log paper results in a curve instead of a straight line (Curve E, Fig. 1).

This fact holds true for any group of logarithmic plots of different slopes, such as, for instance, the back-pressure tests on a group of gas wells.

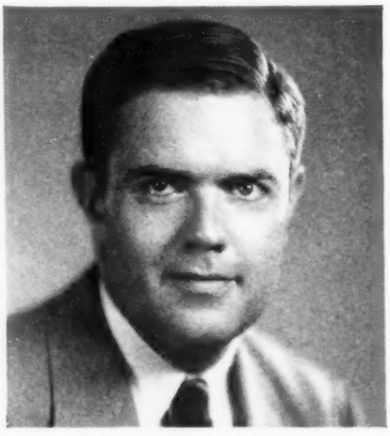
It will be evident also that if the values of x for a given curve are multiplied by a constant percentage factor, and those for another curve by a different factor, the resulting addition will not give a straight line either, unless the slopes of the original lines are identical.

Having demonstrated the theoretical impossibility of a straight line representing the addition of two or more straight lines of different slopes on a logarithmic graph, it might seem that it would be impossible to use a straight line to represent the composite performance of a group of natural gas wells. Actually, from a theoretical standpoint, this is the case, but it is entirely possible that a group of wells may have individual back-pressure curves such that their addition results in a curve that is so nearly straight, between two predetermined values of y, that, for all practical purposes, it may be so considered. This possibility must not, however, be blindly assumed, but must be verified in each case. Some standard must be set up for the maximum allowable deviation of the curve from a straight line within the section considered, and if this amount of deviation is exceeded, the only thing that can be done is to use the curve as it is found, and solve graphically for any functions desired from the curve.

At this point the reader may be wondering why a straight line is desirable, if it can be used. The only advantage comes from being able to calculate points that have not been used in plotting the curve to a greater degree of accuracy than could be obtained by solving graphically for them. In general, a logarithmic plot can be read accurately to only three significant figures, and this means that an error of a magnitude of approximately 1 percent would be inherent. If results closer than this are desired, one must resort to means other than graphic. Also, it is much easier to draw a straight line than a curve, particularly if the curvature is slight.

It is obvious that, if a sufficiently small length of any curve is considered, a straight line could be used to approximate that particular section of the curve, but that this straight line would fail to represent, within the same degree of accuracy, a portion of the curve at some distance from the chosen section, unless the curve should happen to be either a freak curve, or a straight line.

Further, two points may be chosen at random on a curve, and a straight



J. WILLIAM FERGUSON

received B.A. and M.A. degrees from Colorado College, the former in 1930 and the latter in 1932—He had worked part time with the Colorado Interstate Gas Company while attending college and upon completion of his courses became a full-time employee—His experience with the company was as a gas dispatcher, 1929-32; Meter Department, 1932-36, and General Engineering Department, 1936-37—Since July, 1937, he has been with the Canadian River Gas Company—Is assistant gas engineer working on production and transmission problems.

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line drawn between them, but whether this straight line may be used to approximate the curve between the two points must be determined by taking intermediate points on the curve and the line and calculating the errors involved. And, if the straight line is decided to be a sufficiently close approximation to the curve, it is so *only* for the section under scrutiny, but may deviate from the curve in either direction outside the chosen section.

Having touched briefly upon some of the peculiarities of behavior of logarithmic graphs, let us now examine some of the methods advanced by others for the application of back-pressure curves for determining availability of gas from natural gas wells.

The back-pressure curve of a natural gas well is usually represented by the equation:

$$Q = C\,(P_f^2 - P_s^2)^n \quad . \quad . \quad . \quad (10)$$

in which

- Q = rate of flow, usually in cu. ft. of gas per day at a fixed pressure and temperature base; it is plotted as the abscissa, or "x," as we have considered the horizontal coördinate in our previous discussion.
- C = a constant for the particular well, and is usually called the "coefficient."
- P_f = the formation pressure, in lb. per sq. in. absolute.
- P_s = the pressure at the sand face in the well-bore, in lb. per sq. in. absolute.
- n = a constant for the particular well, and is usually referred to as the "exponent" or "slope."

The term $(P_f^2 - P_s^2)$ corresponds to "y," the ordinate, or vertical coördinate in our previous discussion. For brevity, let us introduce a new symbol for this difference in squares, and call it, simply, ΔP^2 (read delta P squared). With this new symbol, equation (10) becomes:

$$Q = C\,(\Delta P^2)^n \quad . \quad . \quad . \quad . \quad (11)$$

or, written in logarithmic form:

$$\log Q = \log C + n \log (\Delta P^2) \quad . \quad (12)$$

The usual procedure employed to obtain a curve representing the performance of a group of natural gas wells is to choose certain values of ΔP^2, such as 10,000, 20,000, 40,000, 80,000, and 160,000, or any others thought advisable. Then the value of Q corresponding to each of these values of ΔP^2 for each well is calculated or read from the back-pressure curves, and tabulated. These values are then added, group by group, to obtain a composite value of Q corresponding to each value of ΔP^2. These are then plotted, and the resulting curve is considered to be the composite curve for the group of wells.

This method is probably the most satisfactory that can be used. Any argument as to its deficiencies may be met fairly with the query, "Have you anything better to offer?" Of course, this usually brings forth another method, but, so far as any published method to date is concerned, no better method has been devised.

The method outlined above corresponds with that contained in the U. S. Bureau of Mines Monograph 7, "Back-Pressure Data on Natural-Gas Wells and Their Application to Production Practices," pp. 99 to 106, inclusive.

It might be mentioned here that the principal reason for most of the peculiar mathematical or pseudo-mathematical methods that have been advanced lies in the fact that some effective value of the formation pressure must be arrived at to represent the various formation pressures of the wells. This becomes increasingly important as the gas pressures in a reservoir decline unequally so that pressure

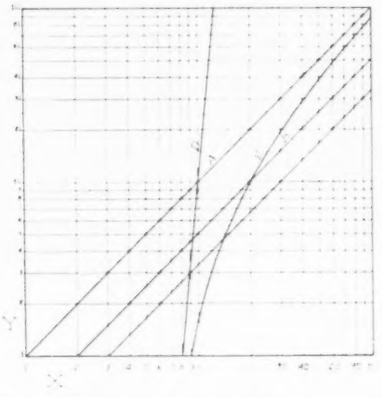

Fig. 1. Illustrating the result of averaging two curves having different n values

gradients are established, and one must fix upon some value of the formation pressure at which the wells, as a group, would operate as though they all had the same pressure. This difficulty is fairly easily overcome by locating on the composite curve, as we have defined it, the point representing the total absolute open flow of all the wells. The value of ΔP^2 for this point may be considered as an effective value, and we may then calculate the effective value of P_f from this effective value of ΔP^2. The significance of an effective formation pressure arrived at in this manner is this: If all of the wells considered had the same formation pressure as this effective P_f, the total absolute open flow would be identical with what it actually is. This method gives an effective P_f quite similar in principle to the center of gravity of an unsymmetrical object.

The effective formation pressure, together with the conventional composite curve, possess the advantage that, so long as the individual well curves remain the same, the composite curve will not be changed, and any changes in individual well formation pressures will simply change the effective formation pressure; and, as it is impossible to predict with any degree of accuracy the changes in individual well pressures over a period of years, this effective pressure is as accurate a basis to begin from in predicting future effective pressures as is any other pressure that might be determined to be an "average" or "weighted average" pressure.

A method advanced by Paul C. White, of the Federal Power Commission,[1] has been of great interest. At first glance, the method seems to be a great advance over previous procedures, but, after examining it thoroughly and testing it with hypothetical cases that can be controlled, it breaks down into contradictions that could be very serious in an actual problem. Because of the rather complicated procedure involved, and the fact that the method does lead to erroneous results in some cases, and is basically unsound, the possibility that in a given case it may be sufficiently accurate does not warrant its use generally, especially in view of the fact that the usual procedure is so simple. It might be said here that White's work exhibits great ingenuity, and that it is only after long study and volumes of calculations that the basic errors in reasoning are revealed.

The method developed by White has been used by the engineers of the Federal Power Commission in the case against the Canadian River Gas Company, Docket G-126.

Several hypothetical cases have been chosen to demonstrate the basic errors of White's methods. These will be considered as briefly as possible, and the writer will be glad to supply additional information to anyone sufficiently interested to desire it.

There are so many different things involved in the problem that it is well to consider each phase separately, when possible, in order to keep from confusing the issue.

Example 1

We shall, then, take up the problem first from a standpoint of the composite curve representing the producing characteristics of two wells having the same back-pressure curve, but with varying formation pressures. The calculations will result in the same type of results, no matter what curve we choose, so for simplicity let us consider the back-pressure curve on both wells to be represented by Curve A, Fig. 2, whose equation is:

[1] "Estimating Availability of Natural Gas Reserves," by Paul C. White, *The Petroleum Engineer*, December, 1940.

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$$Q = 1000\ (P_f^2 - P_s^2)^{0.8} \quad . \quad (13)$$

Now, suppose that these wells have just been completed, and that the pressures in both are the same, so that, for both wells:

$P_f = 487.6899$ lbs. abs., and
$\Delta P^2 = 237{,}841.4$

Both wells, then, have an open flow of 20,000,000 cu. ft. per day, as calculated from (13). By White's method, the composite curve coincides with the conventional composite curve, and passes through the points ($\Delta P^2 = 237{,}841.4$, $Q = 40{,}000$ M. cu. ft.) ($\Delta P^2 = 100$ M., $Q = 20{,}000$ M.), ($\Delta P^2 = 10$ M., $Q = 3{,}169.78$ M.). These values of Q are exactly twice those for the original curve, point for point. The composite curve, of course, has the same slope as the two identical curves, which is 0.8. This composite curve is Curve B, Fig. 2.

Now, suppose that, for some reason, one well remains at its virgin pressure, while the formation pressure in the other drops to 354.3956 lb. abs., so that ΔP^2 for it is 125,596.2. The open flow of the second well is now only 12,000 M. cu. ft. By White's method, the weighted average formation pressure is obtained thus:

	Q. F.	P_f	$Q \times P_f$
	20,000 M.	× 487.6899 =	9,753,798.0 M.
	12,000	× 354.3956	4,252,747.2
Totals	32,000 M.		14,006,545.2 M.

Weighted average P_f = 14,006,545.2 ÷ 32,000 = 437.7045 lb.
Weighted average ΔP^2 = 191,585.2.

White would then draw a curve of slope 0.8 through the point ($\Delta P^2 = 191{,}585.2$, $Q = 32{,}000$ M.) and call that his composite curve. This is Curve C, Fig. 2. But he already had a composite curve with virgin pressure conditions, which does not agree with this new curve. The value of ΔP^2 corresponding to 32,000 M. on the original composite curve is only 179,949.3, so that the effective formation pressure is only 424.2043 lb., or a difference of 13.5 lb. from White's weighted average pressure.

Now, let us suppose that the first well declines from its virgin formation pressure to 469.0496 lb., so that $\Delta P^2 = 220{,}000$, and that the second well suffers an additional decline to 264.5751 lb., so that $\Delta P^2 = 70{,}000$. The open flow of the first well is now 18,790.493 M., whereas the open flow of the second is 7,517.586 M.

Weighting the formation pressures against open flows by White's method gives a weighted average pressure of 410.6206 lb., so that he would have a new composite curve (Curve D) through the point ($\Delta P^2 = 168.6093$ M., $Q = 26{,}308.079$ M.). The value of ΔP^2 corresponding to the total open flow on Curve B is only 140.8730 M., so that the effective value of P_f is now only 375.3035 lb. as against the weighted average figure of 410.6206 lb., or a difference of approximately 35.3 lb.

The reader will realize that the seven significant figures in the above numbers, as in the cases to follow, result from calculation. Such precision is impossible with graphic methods.

It is significant to note here that, if at a later date the formation pressures of the two wells should reach the same value, no matter what, the composite curve obtained by White's method would again coincide with Curve B, so that, depending upon the amount of spread between the formation pressures of the two wells at any time, the composite curve by White's method at that time would diverge more or less from the original curve at virgin pressure, whereas the only thing that varies by the conventional method is the effective formation pressure at a given date. Its variation is at all times controlled by the variation of the individual formation pressures of the wells, so that it does reflect the relative producing ability of the wells, but does not vary as White's method would indicate.

Having avoided the complication of a variation in slopes and the consequent curvature of the composite curve by this Example 1, let us now see what happens if there is a variation in slope. Again, as before, we shall choose our curves to suit ourselves, with the idea in mind that if the methods used will not apply to reasonable hypothetical cases, there is no assurance that they will work with the actual cases we may encounter.

Example 2

As our second hypothetical case, let us consider that we have six wells, all of which have back-pressure curves whose coefficients are 1000, but whose slopes are, respectively, 0.5, 0.6, 0.7, 0.8 (this is the same curve as we chose for Example 1) 0.9, and 1.0. The equations for those back-pressure curves are, then:

Well	Equation
A	$Q = 1000\ (\Delta P^2)^{0.5}$
B	$Q = 1000\ (\Delta P^2)^{0.6}$
C	$Q = 1000\ (\Delta P^2)^{0.7}$
D	$Q = 1000\ (\Delta P^2)^{0.8}$
E	$Q = 1000\ (P\Delta^2)^{0.9}$
F	$Q = 1000\ (P\Delta^2)^{1.0}$

It must be borne in mind from this point on that any composite curve, to be accurate, must have curvature, and that any straight line we may use to represent the composite curve is only an approximation.

For this second example, the calculations will be tabulated so that the methods will be evident, but for later examples, parts of the mechanics of the processes will be omitted. We make the assumption to start with that the range of values of ΔP^2 with which we shall be concerned shall be between 10,000 and 200,000. This gives a shorter length of curve than those considered in White's article, in which consideration was given to values from 2,296,-230 to 4,589. Restricting the length of the curve to be scrutinized has the effect of minimizing the effect of curvature, so that any conclusions we reach will be conservative rather than exaggerating the errors involved.

The first step in our calculations is to tabulate the values of Q for each of the six wells at certain values of ΔP^2, thus:

Well	Quantities at values of ΔP^2 of:				
	10 M.	25 M.	50 M.	100 M.	200 M.
A	100	158	224	316	447
B	251	435	660	1,000	1,516
C	631	1,198	1,947	3,162	5,137
D	1,585	3,299	5,744	10,000	17,411
E	3,981	9,081	16,946	31,622	59,010
F	10,000	25,000	50,000	100,000	200,000
Totals	16,548	39,171	75,521	146,100	283,521

Let us first determine what curve we shall use for our conventional curve to represent the totals shown above. If we arbitrarily choose the values of Q at 10 M. and 100 M., and connect them with a straight line, this line will have a slope equal to the difference between the logarithms of Q at these two points:

log 146,100 M. cu. ft. = 8.1646502
log 16,548 M. cu. ft. = 7.2187455
Difference = "n" = 0.9459047

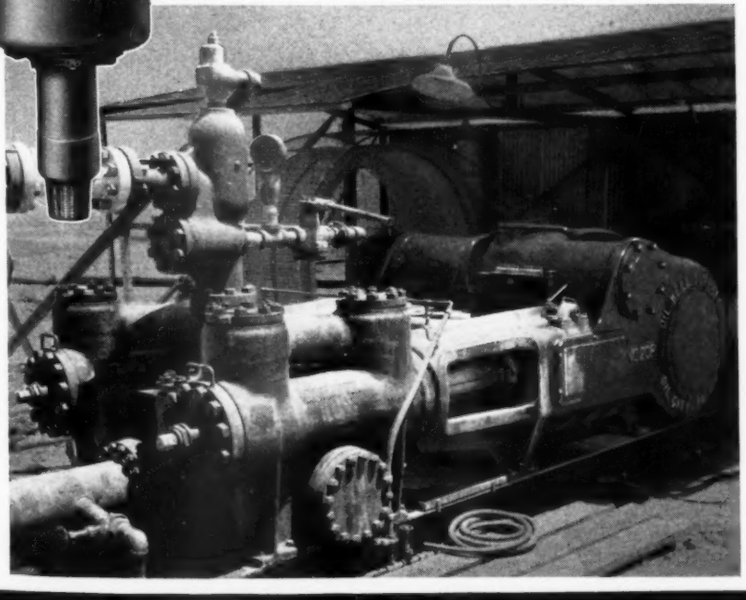
and, to obtain the value of the coefficient of this straight line, we subtract the product of "n" by the logarithm of $\Delta P^2 = 100{,}000$ from the logarithm of

Another deep-well performance record for "OILWELL" equipment

THE LARGE-DIAMETER HOLE (8½ inches at the final depth of 14,622 feet) made the work of this veteran "Oilwell" 27½-inch Oilbath Rotary a particularly tough assignment. Direct-driven by an electric motor, this sturdy machine took the job in its stride and performed with the smoothness and efficiency that are typical of "Oilwell" Rotaries. As now manufactured, "Oilwell" 27½-inch Oilbath Rotaries are of the same reliable general construction with refinements resulting in greater capacity, longer life, and less frequent servicing.

HANDLING RECORD STRINGS of drill pipe is a common occurrence for "Oilwell" Swivels. In drilling Honolulu Oil Corporation's deep well to its final depth an "Oilwell" No. 150-B Swivel, like the one illustrated, supported an extremely heavy string made up largely of 4½-inch drill pipe and including six 40-foot drill collars weighing 95 pounds per foot. An "Oilwell" Swivel of the same series was used in drilling the only well deeper than this one to its record depth of 15,004 ft.

AN "OILWELL" NO. 14-P (7¼" x 14") Power Slush Pump, which had been in service since 1936, bucked pressures far exceeding its rated capacity in drilling this well to 14,110 feet. For the final 512 feet the illustrated "Oilwell" No. 20-P (7¾" x 20") Pump was placed in service after several years of deep drilling performance on other rigs. This high-capacity power pump has ample volume and pressure ratings for the toughest service in any field.



AGAIN and again "Oilwell" equipment has proved its inherent dependability and reserve capacity in drilling to extreme depths. A recent outstanding example is Honolulu Oil Corporation's 14,622-foot well at Buena Vista Hills, California—the second deepest well in the world and the deepest ever drilled with electric power. An "Oilwell" Swivel supported the long string of drill pipe, an "Oilwell" Rotary rotated the string, and "Oilwell" Power Pumps provided vital mud circulation.

It is significant that the "Oilwell" equipment used on this deep well was by no means new. Most items were originally placed in service 3½ years before this well was spudded in on June 1, 1940. This performance, following such a long service life, is clear evidence that "Oilwell" machinery is built to maintain its initial high efficiency.

Deep-well performance records call attention to the outstanding job that is being done in the oil fields by both men and machinery. Not so sensational, but of utmost importance to the equipment buyer, is the consistently efficient day-to-day work performed by "Oilwell" equipped rigs. Send for specifications.

OIL WELL SUPPLY COMPANY

$Q = 146{,}100$ M., which difference is the logarithm of "C":

log 146,100 M. cu. ft. = 8.1646502
log 100,000 = 5; 5 × 0.9459047 = 4.7295235
Difference = log "C" = 3.4351267
from which "C" = 2723.50.

Now, using these values for "C" and "n," let us compare the values of Q for this straight line with the actual values for ΔP^2 = 25 M., 50 M., and 200 M.

ΔP^2 M.	Actual sum M. cu. ft.	Q calculated from straight line M. cu. ft.	Error	Percent error
25	39,171	39,369	+ 198	+ 0.50
50	75,521	75,841	+ 320	+ 0.42
200	283,521	281,447	— 2,074	— 0.74

The pattern of the error shows that, for all values of ΔP^2 between 10 M. and 100 M., the actual values of the curve are less than those shown by the straight line, but for values of ΔP^2 greater than 100 M., the actual values are greater than those shown by the straight line. If we are satisfied with a maximum error of 0.74 percent in our results for any point between 10 M. and 200 M., however, we may safely use this straight line. If not, we then may make use of the method of least squares, choosing these, or any other, intermediate points, and calculating the best straight line that might be drawn through the points chosen. It is almost unnecessary to say that, no matter which points are chosen, a different choice would result in a slightly different straight line. Using the five points we have tabulated, applying the method of least squares results in a straight line whose constants are:

$C = 2650.43$; $\log C = 3.4233160$; $n = 0.948395$.

The comparison between the actual and calculated values, using this straight line, is as follows:

ΔP^2 M.	Actual sum M. cu. ft.	Q calculated from straight line M. cu. ft.	Error	Percent error
10	16,548	16,477	— 71	— 0.43
25	39,171	39,291	+ 120	+ 0.31
50	75,521	75,820	+ 299	+ 0.40
100	146,100	146,312	+ 212	+ 0.15
200	283,521	282,340	— 1,181	— 0.42

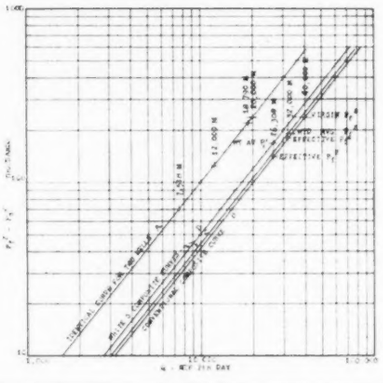
It is obvious that this straight line is a closer approximation to the curve than is the straight line we considered first, but whether it is the best straight line to represent the curve between 10 M. and 100 M. is problematical. On ordinary logarithmic paper, however, either straight line would be indistinguishable from the other, or from the actual curve. Fig. 3 shows some of the well curves, as well as the composite curves. Curve A of this figure is the conventional curve we have been discussing thus far. We shall discuss the curvature and the straight lines to represent the curve of a general case in greater detail in connection with Example 4, and show some of the things that can be done with the various approximations.

If the reader has not already noticed it, it may be well to call attention to the fact that, whereas an arithmetical average of the slopes of the six curves is exactly 0.75, the method we used results in a slope above 0.945, which shows that the producing ability of the wells does have a part in determining the slope of the composite curve.

Now that we have a composite curve to work from, let us assign values to the formation pressures of the wells, and arrive at White's composite curves corresponding to these pressures. First, let us consider that all the wells begin with a virgin formation pressure of 450 lb. per sq. in. absolute, and that, later, the pressures decline in the following manner: Well A, no decline; Well B, declines to 410 lb.; Well C, declines to 370 lb.; Well D, declines to 330 lb.; Well E, declines to 290 lb.; and Well F declines to 250 lb. Finally, let us assume that at a still later date, the wells all equalize to a formation pressure of 100 lb. absolute. The open flows for the six wells would be as follows:

Well	Case 1 P_f	Case 1 O. F.	Case 2 P_f	Case 2 O. F.	Case 3 P_f	Case 3 O. F.
A	450	450	450	450	100	100
B	450	1,527	410	1,366	100	251
C	450	5,182	370	3,940	100	631
D	450	17,585	330	10,706	100	1,585
E	450	59,674	290	27,059	100	3,981
F	450	202,500	250	62,500	100	10,000
Total O. F.		286,918		106,021		16,548

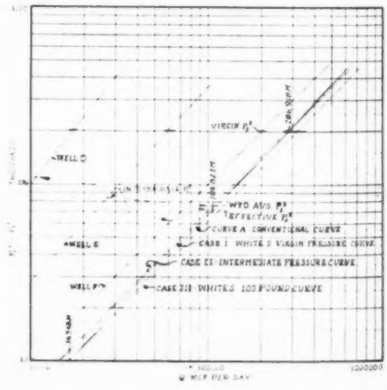
Fig. 2. Illustrating the conditions in Example 1



The value of the weighted average formation pressures and the effective formation pressures are, of course, 450 lb. for Case 1, and 100 lb. for Case 3, as the pressures are the same for all six wells. Weighting formation pressure by open flow for Case 2 gives White's weighted average formation pressure, which is 275.656 lb., whereas the effective formation pressures calculated from the two straight lines we arrived at by the conventional method, are, respectively, 266.924 lb. and 266.840 lb., both of which are more than 8½ lb. less than the weighted average pressure.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer*.

Fig. 3. Illustrating the conditions in Example 2



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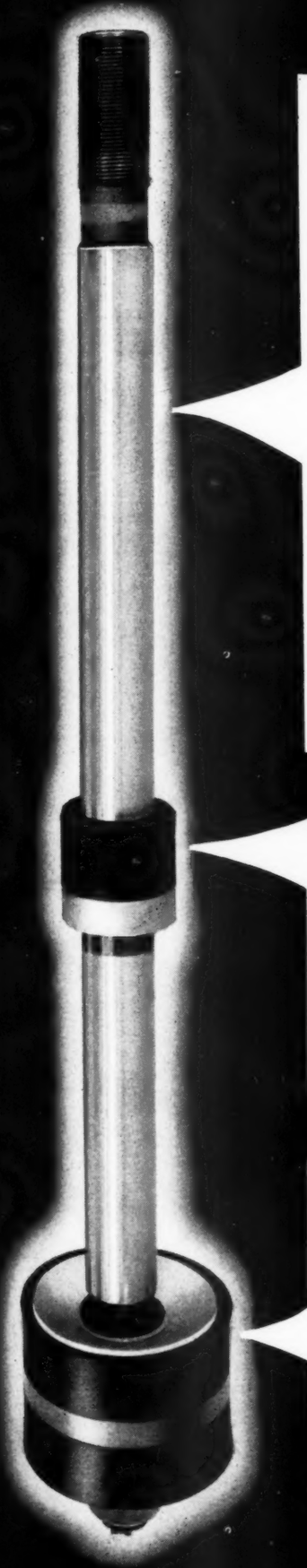

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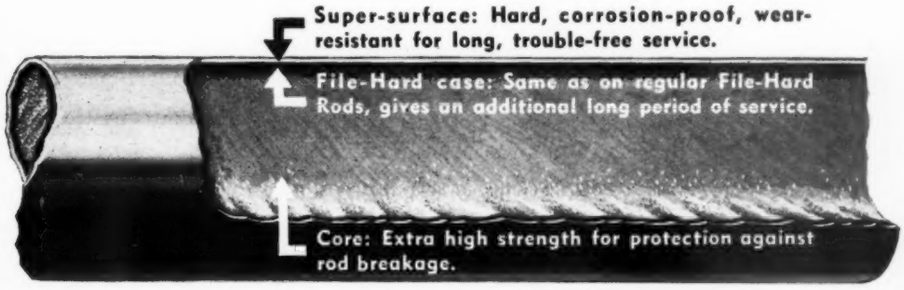
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Thermal Conversion of Gases

Synopsis of Preceding Meetings

The first discussion involved a review of the various hydrocarbons and their thermodynamic qualities as related to the cracking of petroleum and its products. The main hydrocarbons in petroleum and its cracking products are paraffins, olefins, naphthenes, and aromatics. Of these olefins are virtually non-existent in most crude oils.

Points covered in the discussion included the following: (1) chemical stability of compounds; (2) relative crackability of hydrocarbons; (3) energies released or absorbed in cracking; (4) the decomposition reactions, and (5) effect of pressure on reactions.

In discussing the development of cracking, it was pointed out that the ability of petroleum to crack was discovered by the accidental overheating of a topping shell still, resulting in an unexpected straw-colored distillate, which was in reality cracked distillate.

The importance of clean recycle was first recognized when operators of earlier units discovered that clean stocks permitted longer runs with correspondingly small percentage of gas and coke formed.

Additional gasoline will be obtained if a multiple coil heater is used so that more rigid control from the fractionator will permit separate cracking from the various cuts at optimum conditions. Quenching will be essential to correct control of the time and temperature element.

The excessive heat brought to the fractionator from the reaction chamber can be disposed of in a number of ways: (1) the charge may be used as a quench; (2) heat can be exchanged with the charge to any adjacent unit; and (3) the remaining heat must be removed by reflux in the usual way.

The charging stock is less refractory than recycle stock. A cut cracked above its optimum temperature will produce excessive amounts of gas and coke. For maximum gasoline, therefore, it is necessary to separate both the charge and the recycle stock into small cuts. This would necessitate the separate treatment of charge and recycle. These cuts would then be treated at the temperature at which minimum gas is formed and quenched immediately to keep down the formation of polymers and condensation products that reverse the process of cracking and go to form coke. All this procedure would mean many cuts and high recycle ratio. Of course, for practical purposes the above method would have to be modified in order that investment in equipment would be within reason.

When making 70-octane gasoline instead of striving for maximum gasoline yield, a multicoil unit would be used but high reflux ratios would not be feasible for a commercial unit. Ratios from 3 or 5 to 1 were suggested; this would crack the stock deep enough to obtain the desired results. This deeper crack would of course produce a greater percentage of gas and coke, along with more olefins and aromatics. These compounds tend to make the gasoline more unstable and must be handled accordingly. The conclusion reached was that if modern methods are used the yield of 70 octane gasoline would not be more than 5 to 10 percent less than the maximum yield obtainable.

Concerning definitions concerned with cracking the following terms were defined: polymerization is the joining of molecules of the same families; condensation is the combination of unlike molecules in a carbon-to-carbon bond with the elimination of hydrogen or water. These two terms come up frequently in the discussion of the chemical processing of petroleum and its products, sometimes in different shades of meaning.

Class Meeting No. 8 (Continued)

Pupil: The author[1] on page 128 gives some clue as to what he thinks about condensation in considering condensation reactions in cracking:

"First, aromatics and to some extent olefins are responsible for condensation reactions. Aromatization reactions and reactions of dehydrogenation of naphthenes play a very important part in the condensation processes. These reactions forming aromatics are a preliminary stage for further condensation. * * * The condensation of aromatics forms products of a higher molecular weight and boiling range as compared with the original hydrocarbons. * * * The condensation products may be obtained either by condensation of aromatics or by condensation of aromatics with unsaturates. * * * Cracked residues belong mostly to polycyclic aromatic hydrocarbons formed as result of condensation." Coke formation follows the condensation reactions.

Leader: If you desired to obtain the highest possible natural octane number in gasoline, which of the processes we are studying tonight would you select, these processes being:

1. Reforming
2. Polymerization
3. Thermal conversion of gases

Those are the three general headings. Forget the operating expense and think only of the result and quality of the gasoline.

Pupil: I should select all three of them because they are all three different processes. They would go on at the same time. The charging stocks are different; for instance, reforming and thermal conversion of gases are both cracking, but polymerization is the recombining of unsaturated hydrocarbons. Reforming and thermal conversion involve cracking plus polymerization, which is a building-up reaction.

Leader: If you wanted the highest octane number, would you begin with gas?

Pupil: You would begin with reforming and take gas off and polymerize, etc., and would end with reformed naphtha and a polymer with a high octane value.

Pupil: Wouldn't thermal conversion of gases result in a high yield?

Leader: Not so high.

Pupil: Why wouldn't you add one more process to those listed—alkylation?

Leader: We just want the ones we are studying tonight. What is naphtha reforming? Is it cracking or some of these other reactions?

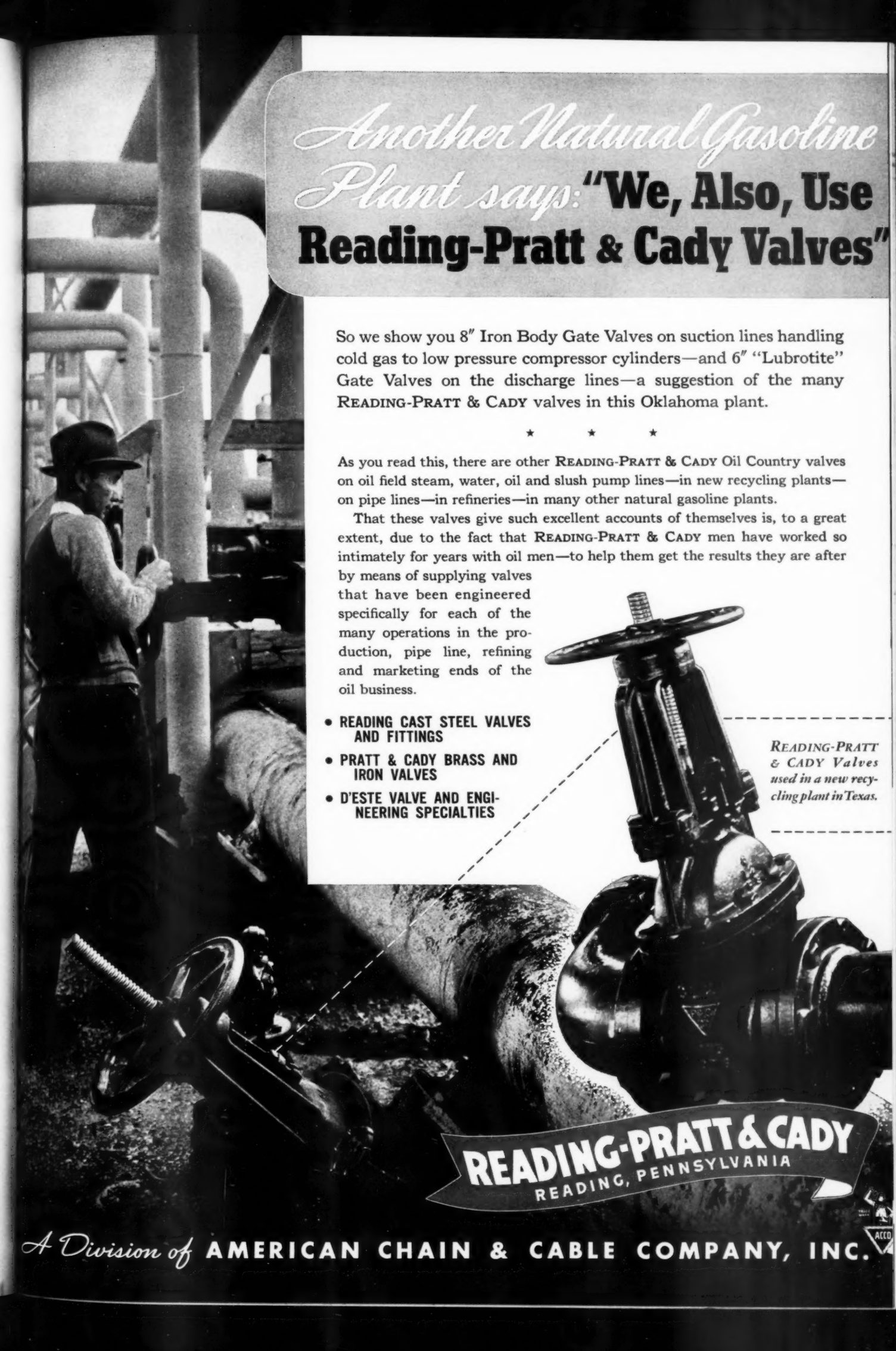
Pupil: It is a form of cracking and also polymerization at the same time. Naphtha is a stable product that has to be heated to somewhere around 986°F. (530°C.) commercially. When subjected to extreme pressure of 250 to 1400 lb. per sq. in. it creates a cracking process, going on into a polymerization of the gases thereby increasing the octane number of the product. You can also obtain an octane number of 70 or higher if you sacrifice some yield, but you do get a good product that can be brought up to a good octane number by the addition of tetraethyl lead.

Leader: I think that is correct.

Pupil: It mentions in the text about the altered commercial practice today which is to blend heavy naphthas and kerosine. Under what circumstances and what determines the reason for using this blend as charging stock?

Leader: What do you think? What

[1]The text used by the class is *Conversion of Petroleum* by A. N. Sachanen. Published by Reinhold Publishing Corporation, 330 W. 42nd Street, New York, N. Y. Price $6.00.



Another Natural Gasoline Plant says: "We, Also, Use Reading-Pratt & Cady Valves"

So we show you 8″ Iron Body Gate Valves on suction lines handling cold gas to low pressure compressor cylinders—and 6″ "Lubrotite" Gate Valves on the discharge lines—a suggestion of the many READING-PRATT & CADY valves in this Oklahoma plant.

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As you read this, there are other READING-PRATT & CADY Oil Country valves on oil field steam, water, oil and slush pump lines—in new recycling plants—on pipe lines—in refineries—in many other natural gasoline plants.

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would be the limiting factor in charging stocks to be mixed with naphtha?

Pupil: Straight-run naphtha is principally composed of paraffinic hydrocarbons. I believe that is what you want in reforming to obtain maximum octane number and a minimum of heavy fractions.

Leader: What is the enemy of all pressure stills?

1st Pupil: Gas.

2nd Pupil: Coke.

3rd Pupil: There is no bigger enemy than gas. Of course, if you get to thermal conversion of gases, maybe it is coke.

Leader: This combining of gasoline and kerosine is sound for the reason that there is little coke to be deposited from a low boiling point kerosine.

Pupil: It probably would depend on the market for gasoline and kerosine, wouldn't it?

Leader: Very much so. I didn't get this question answered, however, on the major reaction that goes with reforming.

Pupil: Cracking, primarily; dehydrogenation to some extent.

Leader: Yes.

What time factor is typical for reforming?

Pupil: Ten to twenty seconds at 1000°F. (538°C.).

Leader: Supposing that this reforming were catalytic instead of thermal —what essential change is there?

Pupil: Lower temperature.

Leader: How much lower?

Pupil: Approximately anywhere from 50° to 100°, I suppose.

Leader: We will say 100° then. What about the time?

Pupil: Ten minutes or more. It is greatly increased.

Pupil: How about yields on that?

Pupil: The yields are increased in catalytic reforming over thermal because with lower temperatures you would not have so much gas loss.

Leader: What is the catalyst?

Pupil: Bauxite, chrome alloys, special aluminum oxide. Several are patented.

Leader: Does it bring a marked difference in results?

Pupil: Well, some authorities think it does.

Leader: Is that a good field for research?

Pupil: Yes.

Leader: I would predict we shall learn much more about catalysts in the next few years—more than any other development of refining.

Pupil: Doesn't the catalyst help more in desulphurization too?

Leader: In catalytic refining, why is desulphurizing important?

Pupil: Most of these catalysts are poisoned by sulphur.

Pupil: The main reason is the corrosion of expensive equipment. They have chrome alloy tubes and heavy chambers and a reduction of corrosion is important.

Leader: What happens to octane when sulphur content gets high?

Pupil: The ill effect is very serious.

Leader: I think it is interesting in catalytic reforming to observe the large reduction in sulphur content that is incidental to the operation. What is an allowable crack per pass for a thermal reforming plant?

Pupil: One time through, with no recycle.

Leader: If there were a yield of 75 percent, that would be 75 percent crack per pass?

Pupil: Yes.

Leader: Is that possible?

Pupil: It would even be higher than 75 percent.

Leader: Yes. In catalytic refining it is even higher. How is it possible to do that with one crack per pass?

Pupil: There is no coke problem in the tubes.

Leader: All right, that makes an outstanding difference. With your recycle ratio cut down, a cracking unit will handle a considerably larger quantity of light oil charge.

Pupil: Actually, it seems to me that reforming is just a process of selective cracking—that is one reason why you can handle it at a high temperature—the molecules are the same.

Pupil: If dehydrogenation is an important factor in reforming, what are the factors that bring about dehydrogenation?

Leader: That's a good question. Can you take a paraffinic hydrocarbon and simply knock off the hydrogen?

Pupil: We said the reaction that occurs last was dehydrogenation and that happens at much higher temperatures. What percent hydrogen is there in the gas?

Pupil: About 80 percent.

Leader: Catalytic or thermal?

Pupil: Catalytic.

Pupil: I would grant you in catalytic reforming you get a considerable volume of hydrogen, but this is different—you get a percentage of aromatics formed. What percentage do you get in the gases?

Pupil: On page 171 of Sachanen, the last table shows 82 percent hydrogen in the gas from catalytic reforming of a Michigan straight-run gasoline.

Leader: Yes, that is catalytic. I think thermal reforming should be considered as cracking principally, with split hydrocarbons resulting, and aromatization.

Pupil: You were talking about greater throughput due to no recycle —you have an offsetting factor in the tendency to vaporize in reforming at higher temperatures and run into high pressures.

Leader: An example is a unit in which (when operating as a cracking unit) the gasoline production may be 1400 bbl. but in reforming the gasoline production may be 1900 barrels.

Pupil: Wouldn't you have a considsiderable saving there from the heat standpoint inasmuch as you don't have all that recycle?

Pupil: A good question is: why there is no coke formed in reforming? There is a minimum of coke.

Leader: What do you think?

Pupil: I think in our original study of cracking, it is indicated that naphtha is a much lighter hydrocarbon and it takes much higher temperatures to crack it. You just don't reach those temperatures unless you get local overheating.

The fact that you make maybe 7 to 10 percent of tar is an indication of those secondary and tertiary reactions.

Pupil: Secondary reactions are speeded-up by high pressures.

Leader: Yes.

Pupil: Isn't coking a condensation reaction?

Leader: Yes.

Pupil: We have condensation in the reforming process.

Leader: Yes.

Pupil: It seems to me the question comes back to the selective charging stocks. When you are charging anything below a 30 gravity, the carbon molecules vary over a range of about C-40 on down to C-300 and 400, but in reforming of naphtha, you very seldom get a hydrocarbon with a longer range than C-18 and C-20.

Leader: Before leaving thermal reforming, I should like to digress to see if we have all the factors in mind. We have talked a great deal about wanting cracked gasolines for automotive use and that road octane was superior with cracked gasoline. Some investigators have gone beyond the current automobile, with ratios of close to 8 to 1 and have found that these cracked gasolines that get such superior results under present-day motor conditions, actually are inferior to saturated paraffins that contain lead when reaching these high compression ratios. That means we should analyze these different processes. Thermal reforming and cracking give you a predominance of unsaturated type of hydrocarbons, whereas catalytic processes may give you a predominance of *iso*paraffins, naphthenics, or naphthenic aromatics, but the important part is that they may be more lead sensitive and when so treated with lead produce much higher octane than with thermal operations. That is another reason why

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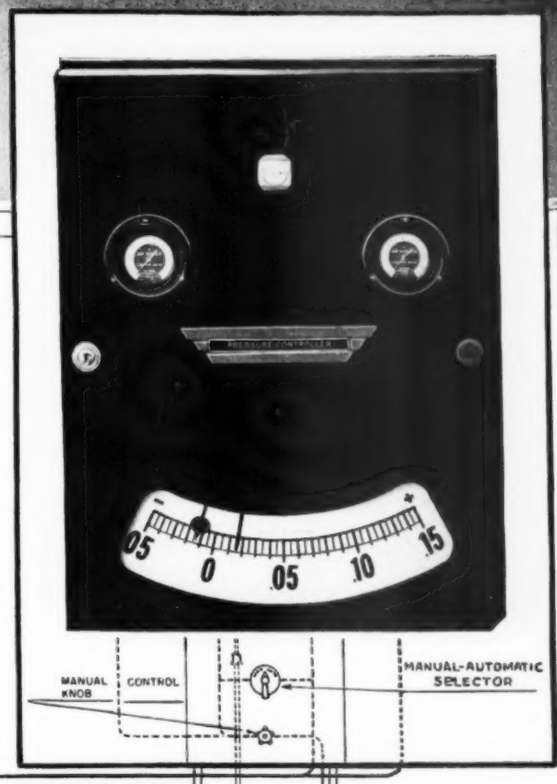

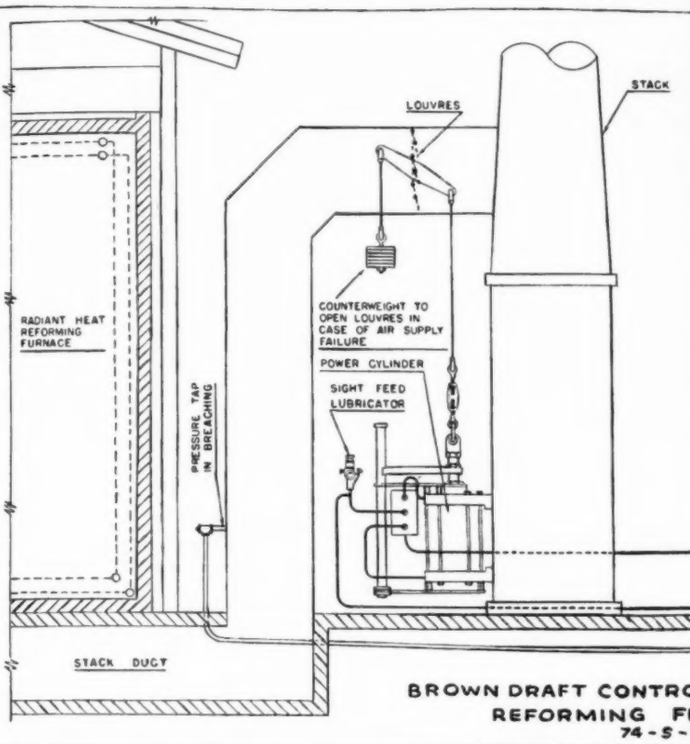

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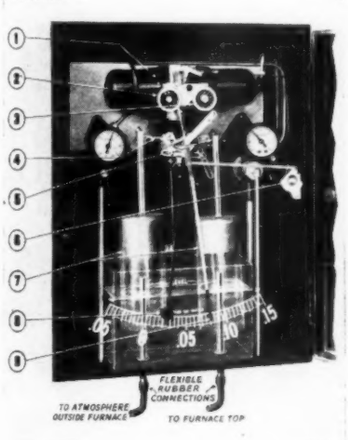

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TO MEASURE AND CONTROL IS TO ECONOMIZE

the catalytic processes are much more important than so far has been generally recognized.

Pupil: Some time back when the Ford Motor Company was supplying the highest compression ratio of any motor car company—at that time the gasoline that operated best was an all-cracked product. Since that time Ford has decreased the compression ratios. If that trend continues—what will that do to the situation?

Leader: On a few specific cars the compression ratio has been reduced, but the industry as a whole has increased compression ratios. The year 1941 is no exception.

Pupil: Is a catalytic polymerization product also more susceptible to lead than a thermal polymerization product?

Leader: Yes, there is reason to think so. How do you increase the octane number of reformed gasoline? If you are making 70-octane number and need 75-octane number, what do you do? Increase the time factor?

Pupil: Nelson[2] says to increase the temperature and the other conditions remain the same.

Leader: Nelson gave a formula, didn't he?

Pupil: Yes. It involves expected degradation for change in octane number.

$$\text{Octane number} = \frac{\text{Change in \% charge to distillate yield}}{\text{Degradation rate}} + \text{original octane}$$

The degradation rate varies with the individual charging stock, its refractoriness, and the process details.

Example:

$$\text{Octane number} = \frac{100-80}{0.68} + 37 = 66.4$$

Leader: What does thermal conversion of gases mean to us?

Pupil: I think first cracking of gas and then polymerization. Polymerization is the recovery of waste products resulting in high octane fuels.

Leader: Can you imagine yourself being in charge of large natural gas production and also a refinery?

Pupil: If so, I should be very much interested in thermal conversion of gases.

2nd Pupil: Some don't seem to be, though.

3rd Pupil: It just depends on whether you have a market for your gas as is, or whether you have to develop a market for it.

1st Pupil: If you have a natural market for your gas, you can realize a greater profit from the gas in its natural state than by reforming it—but here you have excessive gas with no market.

Leader: Will you describe this thermal conversion gas process?

Pupil: There is a 3-stage and a 1-stage.

The gas from refinery processes goes through a heater and through a separator and from there into a fractionator. The first stage of the process is a polymerization process whereby the unsaturates are polymerized and taken out as gas oil.

Pupil: In an oil field the first stage would be cracking or dehydrogenation followed by polymerization. It depends on the source of supply and on refinery gas. The second stage would be cracking of the saturated gases and the third would be polymerization of unsaturated cracked gas.

Leader: Does that appear to be economically sound?

Pupil: Yes, when considering equipment necessary to build it and prices of product yielded.

TABLE I

Conversion of Paraffins to Olefins vs. Temperature and Time

Temperature °C.	Temperature °F.	Reaction time (sec.)	Conversion to Olefins (% by vol.)
		Ethane	
782	1440	1.0	45
782	1440	2.0	51
816	1500	0.5	50
816	1500	1.5	66
843	1550	0.5	70
		Propane	
677	1250	1.0	14
677	1250	2.0	20
704	1300	1.0	30
766	1410	0.5	40
766	1410	1.0	59
793	1460	0.5	57
793	1460	1.0	74
816	1500	0.5	73
816	1500	1.0	76

This table appears as Table 74 on p. 174 in *Conversion of Petroleum* by Sachanen.

Leader: What would your estimate be? When you buy natural gas at 8 cents per M. cu. ft., and it contains butane — what value do you think is realized when n-butane is burned?

Pupil: It would be about 2½ cents per gallon.

2nd Pupil: You would get about 30 cu. ft. to the gallon so that would give you about 30 gallons to 1000 cu. ft. for 8 cents, if it is all butane. That is pretty cheap.

Leader: It is actually ¾ cent per gallon, counting the thermal value.

1st Pupil: The author (Sachanen) states that butane is normally worth about 1.6 to 1.4 cents per gallon.

Leader: Yes, we have some of the cheapest fuel in the world here in the Mid-Continent area. He probably was thinking of New Jersey or New York.

Pupil: What would be the value of that butane recovered and sold as a liquid?

2nd Pupil: Figuring the gas at 45 cents per M. cu. ft., it would be about 2½ or 3 cents.

3rd Pupil: What does liquid butane sell at? Retail, I mean.

Leader: Five cents a gallon.

Pupil: What does it wholesale at?

Leader: I don't know.

Pupil: What would be the value of the butane recovered from one of those plants on the basis of adding increased octane number to our present gasoline?

Pupil: Volatility requirements limit the use of available butane so that surplus butane can hardly be valued as a motor fuel.

Leader: These various processes, including polymerization and others for making use of natural gases will ordinarily pay for a plant in 1 to 4 years. Poly plants alone may pay out in less than a year.

Pupil: Does butane belong in natural gas?

Leader: No. Most natural gas has methane as its largest constituent, with ethane next.

Pupil: Natural gas should not be very high in butane; if it is, it should be processed to remove the butane because it will have some pentane and hexane with it.

Pupil: Butane boils at about 30° or 31°F. and I think it might settle in the lines in the winter time.

Pupil: Due to the partial pressure of butane, that would not necessarily be so in all instances.

Leader: I think practically that it is due to pressures in transit.

Pupil: Most lines now have a main line natural gasoline plant that usually takes out the gasolines that have pentane or heavier, the rest is returned to the line.

Pupil: Every low spot in the line on those big long lines, at least every 7 miles they build a drip outlet in the line to bleed the butane off and it is bled every 4 or 5 days.

Leader: What happens when the pressure is increased?

Pupil: Increased pressures result in partial condensation; pressures are usually high so that quite a lot can be carried in a smaller line and they don't want any butane. It condenses at relatively low pressures.

Leader: Do they want propane?

Pupil: No. For the same reason they don't want the butanes, although it of course remains a gas at somewhat higher pressures.

2nd Pupil: That would be better for a main line, wouldn't it?

3rd Pupil: That's the way all the big lines begin.

2nd Pupil: Natural gases in this area are not so dry as they are in these big gas pipe lines that take gas east—because they don't need to be.

Leader: Local natural gas is about 1050 B.t.u. and these gases that go east often are somewhat under 1050,

[2] *Petroleum Refinery Engineering* by W. L. Nelson. Published by McGraw-Hill Book Company, Inc., New York, N. Y.

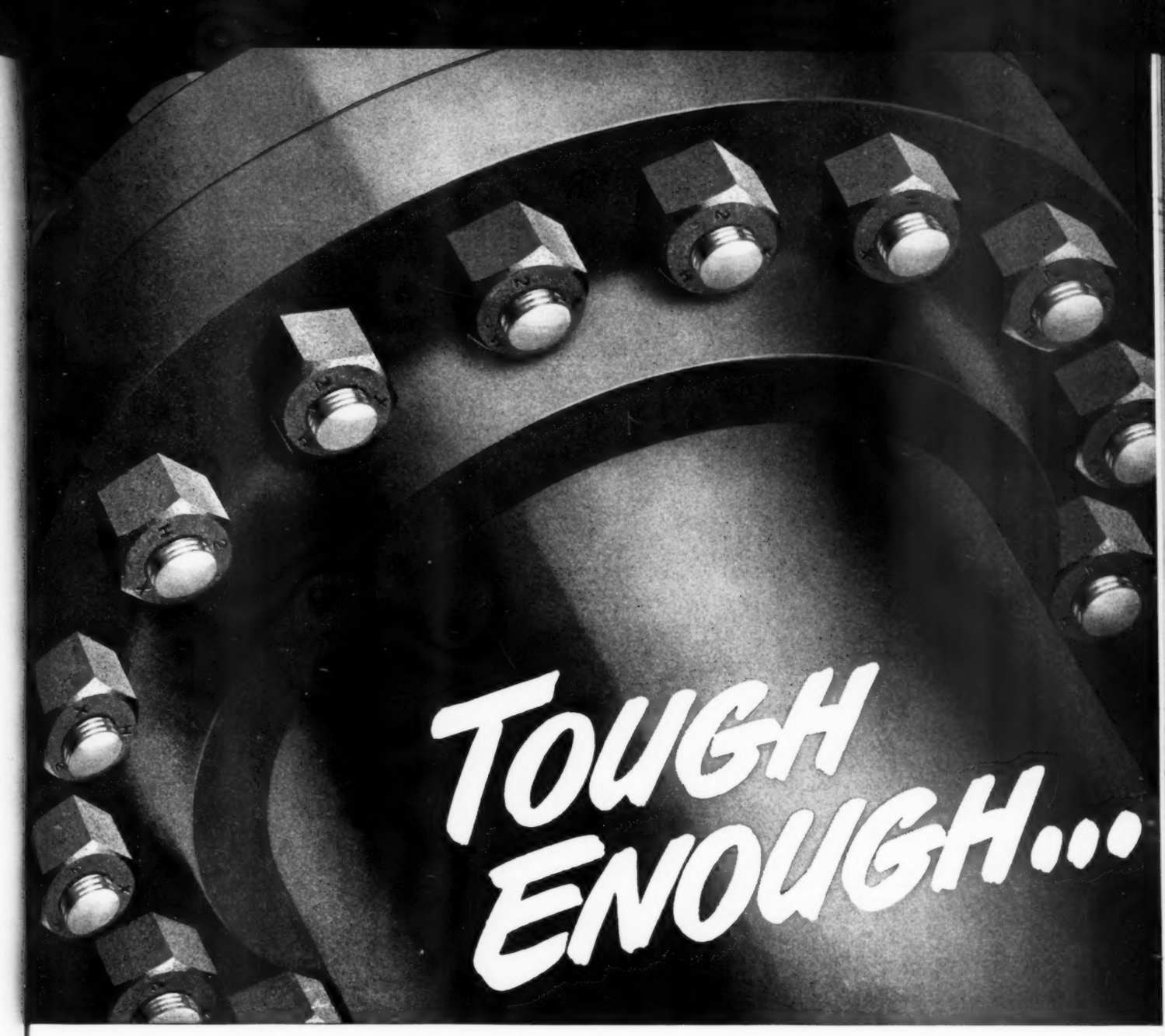

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TABLE 2

Polymerization of Olefins vs. Temperature and Time

Temperature °C.	Temperature °F.	Pressure (lb./sq. in.)	Time of Reaction (min.)	Conversion to Polymers (% by wt.) of Ethane	of Propane
399	750	500	10	4	2
399	750	1000	10	14	4
399	750	1000	30	49	13
399	750	3000	10	52	24
399	750	3000	20	73	54
454	850	500	10	65 (?)	45 (Extrapol)
454	850	1000	10	56	50 (Extrapol)
454	850	1000	20	65	57
454	850	3000	10	76	68

This table appears as Table 75 on p. 175 in *Conversion of Petroleum* by Sachanen.

indicating the stripping of those hydrocarbons that have high thermal values.

Pupil: Phillips remove butane, pentane, etc., from this natural gas and use it in their Poly plant before they put it in these main distributing lines.

Leader: And so do the others remove it also.

Pupil: I don't think we have an over-abundance of aviation supply.

Leader: We have a potential shortage, due to lack of facilities.

Pupil: There has been considerable talk about re-pressuring oil fields. Is there a possibility that polymerization could be occurring underground when you do re-pressure natural gas?

Leader: I think there is no reaction there, due to relatively low temperatures.

Pupil: You do have high pressures, only one commercial alloy listed that would stand such temperatures for any appreciable time. This offers a definite construction problem.

Pupil: I should like to ask your opinion—why does the ethane require such high temperature?

Pupil: Short molecule—severely resistant.

Leader: First we have cracking, and then polymerization in which such severe conditions are not required. If you take 1550°F. (843°C.) for ethane and 30 sec. for cracking couldn't we take it to 1000°F. (538°C.) and get the same results?

Pupil: I doubt it. Because at a certain temperature the reaction is so slow it will not do any good, and 1000° is probably in that range. And the time in the furnace is so short, unless we go to an unreasonably large furnace.

TABLE 3

	Initial	Desulphurized		
% Sulphur:	0.037	0.008	0.004	0.002
Clear	67.2	69.5	69.6	69.7
1 cc. tetraethyl lead	75.6	80.0	81.0	81.4
3 cc. " "	82.1	85.3	86.8	87.5
6 cc. " "	86.6	91.2	92.8	93.2

This table appears on p. 332 in *Conversion of Petroleum* by Sachanen.

but most of the butane or lighter gases are saturated and do not lend themselves to poly reaction.

2nd Pupil: In connection with polymerization and the cracking reaction occurring underground, I have heard of a process in Europe of adding oxygen to the gas while they are repressuring the field and causing the cracking or polymerization process to take place underground.

Leader: I should like to refer you to Tables 74 and 75 on page 174 of Sachenen's text. (These tables appear here as Tables 1 and 2.)

You will notice in Table 1 that for ethane the best temperature is 1550°F., and for propane 1500° resulting in 70 percent yield of olefins from ethane and 76 percent yield of olefins from propane. What does that mean to you in a refinery, and what would you do with that process; what metals would you use?

Pupil: In Nelson's text there was

Leader: So that temperatures are all-important too, in the design.

Do you have any questions on this conversion as discussed in these two tables? What kind of gasoline is produced by thermal conversion?

Pupil: The gasoline is about 79 A.S.T.M. octane number; add 3 cc.'s of lead and it increases to 88.5.

Pupil: On page 332 of the text there is a table on the effect of sulphur on these octane numbers. (This table appears here as Table 3.)

2nd Pupil: Yes the percent sulphur content is 0.037 and it desulphurizes down to practically nothing. Beginning with 67.2 and improving it to 69.7 by desulphurizing.

3rd Pupil: For catalytic poly gasoline, the original octane number of 81 increases to 85 after adding 3 cc. of lead per gal. Hydrogenated gasoline of 85 octane increases to 90 when using 3 cc. of lead.

Pupil: I believe Phillips in the neohexane process have a product that is very sensitive to lead too.

Leader: Yes, because of its paraffinic nature due to the alkylation. In contrast, some of the catalytically cracked gasolines that have a high acid heat value and are not acceptable to the government, are being blended with alkylated gasoline in order to get down to the required point.

Pupil: I thought that was one point that the Houdry process was noted for.

Pupil: It was stated that process had lower acid heat and the product was more acceptable for aviation gasoline.

Leader: The catalytic processes are producing gasolines that are showing a decidedly better lead susceptibility than thermal processes. Lower acid heat values and improved lead susceptibility seem to accompany lower charge rates to the catalyst cases.

Pupil: Speaking of acid heat, what do you mean by that?

Leader: Sulphuric acid is mixed with gasoline under specified conditions and the increase in temperature is a measure of the reaction.

Pupil: Shouldn't we be analyzing these octane numbers on the basis of blending value rather than octane number?

Leader: It must be reckoned with. If you have poly gasoline of 80 octane and you blended that with 50 octane in equal proportions—the numerical value would be what?

Pupil: 65.

Leader: If it made 75—that would give you a calculated value of 100, so that would be referred to as the blending value. Actually, this would not be the case with such large proportions of the high octane material.

Pupil: Catalytic reforming value is 90 octane number and has a blending value of over 115.

Leader: Referring again to thermal conversion of gases (which is really cracking and polymerization) when I said we had excellent quality, I was referring to the process being carried to the extreme at which it will result in practically 100 percent aromatics. The gravity of gasoline produced in this manner would be about 31-32 A.P.I., which is approaching laboratory benzol. I want to bring out the difficulties with the materials when working at these highest temperatures; men have been burned to death by experiments. Be sure to have your metals fit your temperature conditions.

EDITOR'S NOTE: This series will be continued in an early issue of *The Petroleum Engineer.*

P 615.635.4

Laboratory Tests of Cathodic Protection of Steel in Various Corrosive Solutions

PETROLEUM ENGINEER Exclusive Feature

☆ Results indicate virtually complete protection at current density of 10 ma. per sq. ft.

by W. Ryland Hill

Assistant Professor of Electrical Engineering, University of Washington

IN order to obtain data on the cathodic protection of steel, a series of laboratory experiments was made under carefully controlled conditions on nearly 300 steel samples tested in both solutions and soils. The tests were planned with two aims: (1) to make laboratory tests under conditions similar to those encountered in practice for the purpose of working out some practical method of measuring the degree of protection obtained from a cathodic installation, and (2) to measure the corrosion loss with various amounts of cathodic protection under a number of ideal conditions for the purpose of determining which factors have the greatest effects on the protection obtained. A discussion of the tests of cathodic protection in soils was published in a former article.[1] The remaining tests, all of which were made in solutions, are described in the following paragraphs.

The greater number of the tests of cathodic protection in solutions was made under idealized conditions for the purpose of determining the following:

(1) The effect of concentration of the corroding solution.
(2) The effect of variation of the negative or positive ion in the corroding solution.
(3) The effect of hydrogen-ion concentration in the corroding solution.
(4) The effect of time on the protection obtained.
(5) The relationship between the current density and the metal-to-solution potential required for protection from corrosion in solutions.

In general it was found that variations in the time of exposure or of the concentration and composition of the corroding solution had only minor effects on the current density required to protect the metal surface from corrosion, and that this protection was usually indicated by some polarization.

[1] "Laboratory Tests of Cathodic Protection in Soils," by W. Ryland Hill. *The Petroleum Engineer*, March, 1941.

W. RYLAND HILL

graduated from the University of Washington in 1934 with the degree of bachelor of science in electrical engineering—Followed two years as commercial radio engineer with Northern Radio Company of Seattle, then two years as a graduate student and teaching assistant at the University of California where he obtained his master's degree—From June, 1938, until September 7, 1941, was with Engineering Department of the Standard Oil Company of California—On the latter date he assumed new duties as assistant professor of electrical engineering, University of Washington, Seattle, Washington.

Method of Test

In making the large number of tests required for establishing the effectiveness of cathodic protection over a wide range of chosen conditions, the steel specimens were tested in individual corrosion cells as shown in Fig. 1. Each cell consisted of a 1-in. glass tube approximately 6 in. long with one end ground flat, to which a steel coupon was sealed. This method of construction exposed a uniform steel surface to the solution without including any cut edges where working of the metal might have changed its characteristics, and provided an initially uniform current density over the metal surface. Although formation of localized anodic and cathodic areas on the metal surface prevents the current density from remaining uniform over the surface, conditions were such that the density would have been equal at all points if the metal surface had remained uniform. The horizontal position of the test coupons was chosen to provide as uniform an environment as possible at the steel surface and reduce the effects of varying oxygen concentration at different depths in the solution. Each cell was provided with a carbon anode and a glass tube for introducing a slow current of air to stir the solution and to maintain the oxygen concentration. Air was introduced at the rate of 50 cc. per hour; this amounted to about one bubble each 5 seconds, which was sufficient to stir the solution slowly without disturbing the corrosion products on the metal surface. Several test runs were made without aëration to observe the effect on the cathodic protection obtained.

Power for cathodic protection was supplied by a vacuum tube rectifier adjusted to a constant output of 20 volts (d-c.). The negative terminal was connected to all the metal coupons in the group under test, and the positive terminal was attached to each carbon anode through an individual high resistance of known value. More than 90 percent of the voltage drop occurred in the resistors so that variations in the e.m.f. of any cell affected its current only to a minor extent, always less than 5 percent. The samples were tested in groups of seven for each different solution, one with no electrical protection and the remaining six protected with current densities of about 0.1, 0.3, 1.0, 3.0, 10, and 30 ma. per sq. ft. An individual coupon was used for each of the points shown on the curves to be discussed. All tests were made at a temperature of 20°C. ± 2°.

The steel coupons used in the test were cut from a single piece of 20-gauge cold-rolled mild steel containing approximately 0.15 percent carbon. The coupons were then ground with No. 240 abrasive cloth until all the original surface had been removed from each. After being dusted with a

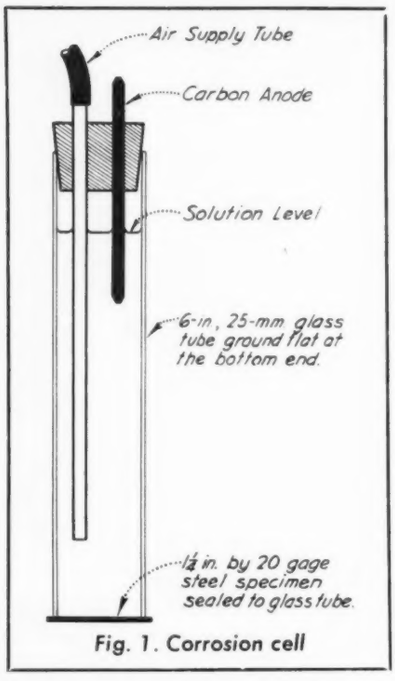

Air Supply Tube
Carbon Anode
Solution Level
6-in., 25-mm glass tube ground flat at the bottom end.
½ in. by 20 gage steel specimen sealed to glass tube.

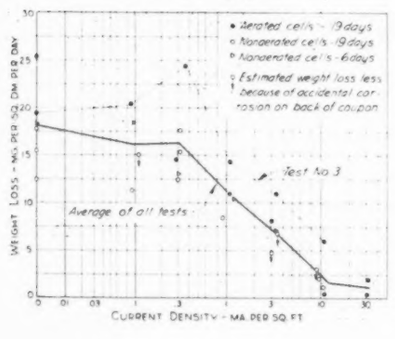
Fig. 1. Corrosion cell

brush, each specimen was weighed to the nearest 0.2 mg. The surface was not touched by hand from the time of grinding until removal from the cell for the final cleaning and weighing. The corroded coupons were cleaned by softening the scale in 20-percent acetic acid followed by brushing in hot soapy water and immediate drying. This was found to remove all the corrosion products without removing any of the metal.

The test solutions were compounded of reagent grade chemicals and distilled water, each bath of solution being shaken thoroughly to saturate it initially with oxygen. A volume of 70 cc. was placed in each cell.

Metal-to-solution potentials were measured with a potentiometer in conjunction with a copper-saturated copper-sulphate half-cell used as a reference electrode. As it is common practice to use this type of electrode for making electrical measurements in cathodic protection work, no subtraction has been made for the electrode potential. To eliminate any IR potential drops in the solution when determining the metal-to-solution potential, the solution contact was made by a small glass tube inserted in the corrosion cell and touching the bottom. The lower end of this tube was cut at a slant to provide an effective entrance a short distance above the metal surface, and the top was tightly packed with absorbent cotton. By drawing the cell solution into the tube until it penetrated the absorbent cotton a continuous liquid path was established from the surface of the test coupon to a convenient point outside the cell. After measuring the potential between this point and the metal coupon, the tube was withdrawn and the solution in it discarded to prevent pollution of the test cell liquid.

Fig. 2. Comparison of six tests in 0.1 N NaCl


Aerated cells - 19 days
Nonaerated cells - 19 days
Nonaerated cells - 6 days
Estimated weight loss less because of accidental corrosion on back of coupon
Test No. 3
Average of all tests
WEIGHT LOSS - MG. PER SQ. DM PER DAY
CURRENT DENSITY - MA. PER SQ. FT.

Test Results

Reproducibility. In making the solution tests six different groups were run in 0.1 normal sodium chloride to observe the reproducibility of the tests and the effect of aëration of the cells. The test results are shown by Fig. 1 with the corrosion rate of the steel coupons in mg. per sq. dm. per day plotted as a function of the protective current density in ma. per sq. ft. Unfortunately leakage of the seal between the glass and the coupon spoiled some of the early tests in nonaërated solutions. For those tests in which corrosion from leakage was slight the points have been shown, but with a small arrow to indicate that the true corrosion rate was actually less than the value measured.

The curves show that the corrosion rate for the nonaërated cells tested 19 days was less than the average for all six tests. The 6-day tests in nonaërated cells, however, were just about up to the average. This can be explained by the fact that the solution was practically saturated with oxygen to begin with, so that for the first few days the corrosion rate was at a maximum, gradually dropping as the oxygen was consumed.

It is interesting that all the points from one particular run, shown connected by the fine line, were considerably above the average value. This is difficult to explain. Although it is to be expected that the corrosion rate of any one specimen might vary considerably from the mean depending on the chance establishment of the proper conditions at the metal surface, it is not to be expected that a whole group of test coupons would show this tendency. This is especially true inasmuch as all the specimens were handled in a perfectly random manner up to the point where the solution was added to the cells. The solutions were made up

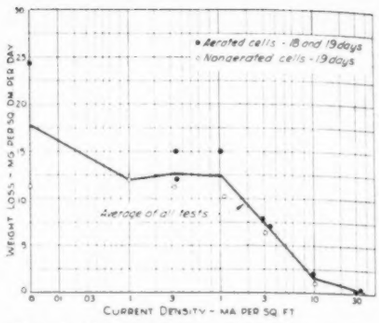

Aerated cells - 18 and 19 days
Nonaerated cells - 19 days
Average of all tests
WEIGHT LOSS - MG. PER SQ. DM PER DAY
CURRENT DENSITY - MA. PER SQ. FT.

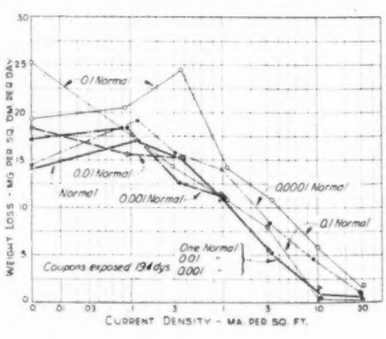
Fig. 3. Comparison of three tests in 0.1 N Na_2SO_4

with reagent grade chemicals and distilled water, and this particular one with a group of other sodium-chloride solutions, so that the only probable mistake could have been in solution concentration, which later was shown to have little effect. The only other reasonable conclusion is that the whole group of points was high by the mere chance that each point fell near the upper limit of the normal range of values to be expected for each current density. If there is a 20 percent chance that a given point will be near the upper limit of the normal range of values, then the chance that six of the points will fall near the upper limit is 0.2^6 or about one in 15,000.

Fig. 3 for 0.1 normal sodium sulphate shows less variation than for the sodium-chloride cells but with the nonaërated tests indicating a lower corrosion rate. It is apparent from the curves, however, that aëration of the cells was of minor consequence in affecting the corrosion rate at the higher current densities for the length of time tested, and that it produced no definite effect so far as determining the current density at which the metal was completely protected. With the exception of Test No. 3 in sodium chloride, the reproducibility of the test points is fairly good considering the usual difficulty in obtaining consistent measurements of corrosion rate.

Effect of Solution Concentration:

Fig. 4. Comparison of tests in several concentrations of NaCl



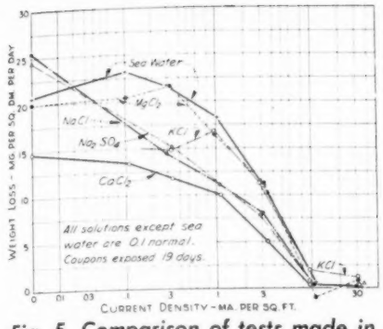


Fig. 5. Comparison of tests made in various solutions

The effect of solution concentration on the effectiveness of cathodic protection is shown by Fig. 4 giving the results of tests made in sodium-chloride solutions varying from 1.0 normal to 0.0001 normal in strength. Two curves for 0.1 normal solution are given, one of them representing Test No. 3 shown in Fig. 2. With the exception of the abnormal Test 3 data the curves for 1, 0.1, 0.01 and 0.001 normal are substantially the same for all current densities above 0.1 ma. per sq. ft. indicating that the solution concentration had little effect on the cathodic protection obtained and that a current density of about 10 ma. per sq. ft. was sufficient practically to eliminate corrosion. For some reason the 0.0001 normal curve indicates the need for a current density of as much as 30 ma. per sq. ft. to obtain complete protection. As no other tests were run with this concentration it is not known whether this curve is unusual or whether other tests at the same concentration would have given results more like those at higher concentrations. It hardly seems reasonable that concentration would have little effect over the wide range from normal to 0.001 normal with a sudden change in the vicinity of 0.0001 normal.

It is interesting that dilute solutions showed corrosion rates as great as those found for the more concentrated solutions. The usual experience is that concentrated solutions are more corrosive; a metal structure in sea water, for instance, is more rapidly destroyed than one in fresh water. This greater corrosiveness of more concentrated solutions is attributed to the lower resistance of the stronger electrolyte permitting a greater flow of current from the anodic to the cathodic areas of the metal surface. In a small laboratory test cell the metal area is restricted and the effect of local corrosion cells is diminished. As a result the effect of solution strength on the corrosion rate is reduced.

Effect of Solution Composition

The effect of solution composition on the corrosion rate under electrical protection was observed by a series of tests run in solutions containing the chloride, sulphate, calcium, magnesium, potassium, and sodium ions, representing the ions most commonly found in soils and natural waters. Fig. 5 shows the curves obtained. It is apparent that cathodic protection was equally effective in all of the tests, a current density of about 10 ma. per sq. ft. being required to reduce the corrosion to practically zero. (The apparent gain in weight of one point on the magnesium chloride curve is the result of a weighing error.) This is interesting. As the basic corrosion reactions involve only the metal, water, and oxygen it is not unreasonable to expect that the ions used in the electrolytes would have little effect on the mechanism of electrical protection other than to decrease the resistivity of the solution unless

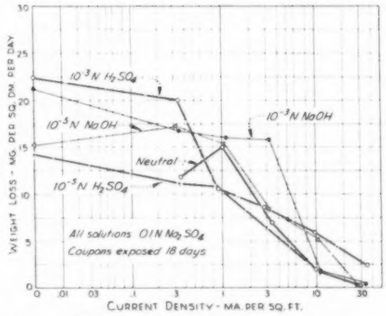

10^{-3} N H_2SO_4
10^{-5} N NaOH
10^{-3} N NaOH
Neutral
10^{-5} N H_2SO_4
All solutions 0.1 N Na_2SO_4 Coupons exposed 18 days
WEIGHT LOSS - MG. PER SQ. DM. PER DAY
CURRENT DENSITY - MA. PER SQ. FT.

Fig. 6. Effect of hydrogen ion concentration on cathodic protection

they assist in the formation of surface films or deposits leading to passivity of the metal or interfering with the normal corrosion rate.

A test in sea water was also included with the other solutions, chiefly as a matter of practical interest because sea water is one of the most common electrolytes encountered in corrosion problems. Sea water consists essentially of a solution of sodium chloride with some magnesium and calcium chlorides and a little sulphate, the total concentration being about 0.5 normal.

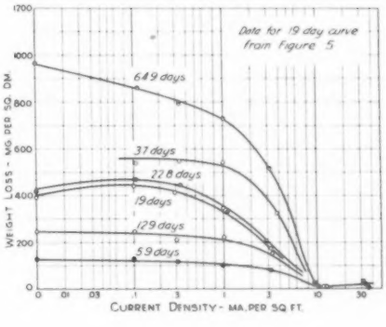
In the electrolyte surrounding the metal under protection, the positive ions are attracted to the cathode and are there liberated as metallic sodium, potassium, calcium, or magnesium as the case may be. With sodium or potassium there is an immediate reaction with the water to form sodium or potassium hydroxide, which are soluble and diffuse from the surface. With calcium, calcium hydroxide is probably first formed and then converted to the insoluble carbonate by reaction with the dissolved carbon dioxide, thus forming a film on the metal cathode. With magnesium the insoluble hydroxide is immediately precipitated. Such films were observed on all the completely protected coupons exposed in calcium and magnesium chlorides and sea water, but none was found on coupons run at lower current densities. This is in accord with practical experience in applying cathodic protection to pipe lines submerged in sea water where heavy lime-like scale deposits have been found at all points where the current density exceeded about 10 ma. per sq. ft. Consequently the appearance of this scale can be used as a criterion for establishing the coverage provided by a cathodic installation protecting a submarine pipe line. Analysis of the scale formed in sea water shows it to be composed essentially of calcium carbonate and magnesium hydroxide.

Effect of Hydrogen-Ion Concentration

The effect of hydrogen-ion concentration was observed in 0.1 normal solutions of sodium sulphate to which were added small amounts of sulphuric acid or sodium hydroxide. With the sodium sulphate acting as a buffer it was possible to vary the hydrogen-ion concentration without appreciably affecting the sodium- or sulphate-ion concentrations. The range covered was from about pH 4 with the solution 0.001 normal in sulphuric acid to about pH 11 with it 0.001 normal in sodium hydroxide. The results are given in Fig. 6.

Three of the five curves show good protection from corrosion at 10 ma. per sq. ft. which seems to be typical of most of the solutions used. The curve for 0.00001 normal sodium hydroxide (about pH 9), which might be expected to fall between the curves for 0.001 normal sodium hydroxide and the neutral solution, shows a corrosion rate of 5 mg. per sq. dm. per day at 10 ma. per sq. ft. but this may be one of the random variations that makes it advisable to repeat each test several times to obtain indicative results. The

Fig. 7. Effect of time on cathodic protection in sea water



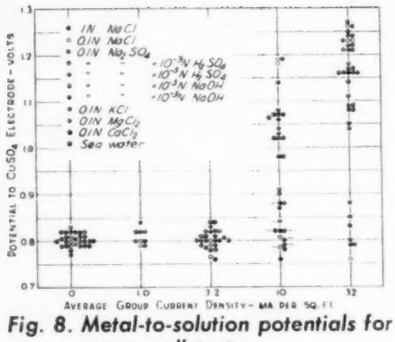


Fig. 8. Metal-to-solution potentials for all tests

curve for 0.001 normal sulphuric acid, on the other hand, is well above zero for a current density as high as 35 ma. per sq. ft., which probably represents a real departure and indicates that a greater current density is necessary completely to protect a steel surface from corrosion in solutions of high hydrogen-ion concentration.

Effect of Time

To investigate the effect of time on the process of electrical corrosion protection a series of tests was made in sea water, tests on five groups of specimens being begun simultaneously and terminated at intervals over a period of two months. Fig. 7 shows the curves obtained. A sixth curve for an exposure of 19 days is taken from Fig. 5 and shows excellent reproducibility even though the groups were run at different times.

These tests were made to see if the effectiveness of cathodic protection might possibly increase with time because of formation of surface films and changes in the character of the metal-liquid interface after applying the electrical potential and current. The curves in Fig. 7 show that the current density required for complete protection was as great after two months as at the beginning, and that the total corrosion for a given current density continued to increase with time for all current densities lower than that required practically to stop corrosion. The rate of corrosion in every case decreased somewhat with time (common in corrosion processes) but there appears to be no marked tendency for this decrease to be greater for current densities approaching the fully protective value.

All the curves show practically perfect protection at a current density of 10 ma. per sq. ft. but it should be noted that the corrosion loss for the coupons run at 35 ma. per sq. ft. is a little greater. This corrosion loss, however, is still unimportant compared to the corrosion loss without any protection. In every case the coupons supplied with current densities of more than 9 ma. per sq. ft. were coated with scale; those run at lower densities showed none.

Metal-to-Solution Potentials

During the test runs at constant current density, measurements were made of the potential differences between the corroding metal coupons and the adjacent electrolytes. A graphical tabulation of these readings is shown in Fig. 8. The points have been grouped according to five average current density values with each solution indicated by a particular symbol. Potential values are shown to the nearest 5 millivolts.

The chart clearly shows the clustering of the potential values near the 0.8 volt value for current density groups of 3.2 ma. per sq. ft. and lower. The potential measurements at 10 ma. per sq. ft. show considerable polarization in many cases although several of the coupons showed practically no potential change. If the points for specimens not protected by a current density of 10 ma. per sq. ft. (indicated by a horizontal bar) are eliminated from consideration, the remaining values show that for protected coupons there is a 75 percent chance of being polarized to 0.9 volt or more, and a 60 percent chance of being polarized to more than 1.0 volt. Solutions forming surface films seem to be more stable than those not forming films; the samples in calcium, magnesium, and sea water solutions were well polarized at 10 ma. per sq. ft.

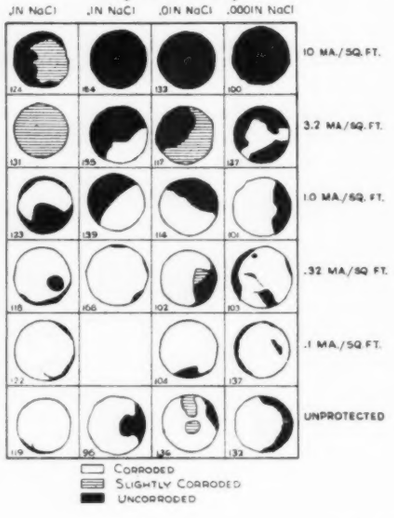


Fig. 9. Corrosion distribution on exposed coupons

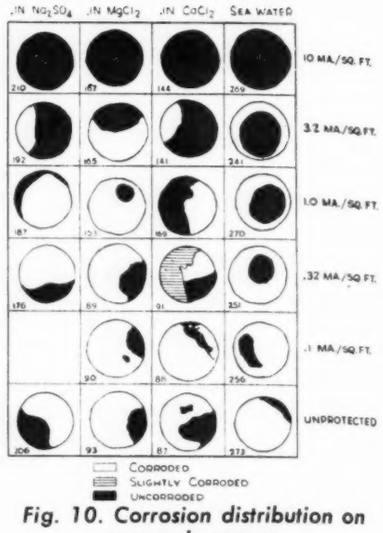


Fig. 10. Corrosion distribution on exposed coupons

TABLE I
Anodic Corrosion Rates of Test Coupons
(mg. per sq. dm. per day)

Current density of group, ma. per sq. ft.	*3*	*1*	*0.3*	*0.1*	*0.0*	*Average loss*
Solution:						
0.1 N NaCl		28.8	28.1	23.3	20.2	25.1
0.1 N NaCl	26.2	21.9	15.5		33.4	24.2
0.01 N NaCl		20.0		18.2		19.1
0.0001 N NaCl	24.6	19.3	20.0	22.9	17.8	20.9
0-1 N Na_2So_4	26.7	19.5	16.0			20.7
0.1 N $MgCl_2$	19.3	18.4	31.2	24.6	24.5	23.6
0.1 N $CaCl_2$	22.6	21.8		15.8	24.6	21.2
Sea water	32.4	26.5	24.7	25.8	21.6	26.2
Average	25.3	22.0	22.6	21.8	23.7	23.0

In the other solutions it was possible to dispel the polarization by vigorously stirring the solution after which the potential would slowly build up again, sometimes requiring several hours to return to a high value. In some cases readings made at different times on a single cell showed variations as large as 0.3 volt.

In general it appears that the presence of a polarization change of 0.1 volt or more above the normal metal-to-solution potential is a good indication of protection, but the absence of polarization does not necessarily indicate that the metal surface is not protected.

Corrosion Distribution on Coupons

Examination of the corroded coupons exposed to the solutions discloses

that the corrosion was not uniform over the surface of the metal. Instead, the surface is irregularly marked, part of the area being corroded and part perfectly preserved. This was probably caused by the division of the surface into anodic and cathodic areas, the anodic areas corroding and the cathodic areas remaining unattacked. Drawings showing accurate tracings of the corrosion distribution for a number of exposed coupons are given in Figs. 9 and 10. In each case the circular area represents the portion exposed to the solution. A few areas, slightly corroded but apparently cathodic for the greater part of the time, are shown by cross-hatching.

A study of the drawings shows that the effect of the cathodic protection is not only to diminish the average corrosion rate of the specimen, but also to reduce the portion of the area experiencing corrosion. As the current density applied to the metal surface is increased, the anodic corroding area becomes smaller until a point is reached where it disappears. At this current density the steel experiences no corrosion. By computing the corrosion rates for the anodic areas from the weight loss and extent of each anodic area, it is found that the corrosion rate on all of these areas was substantially the same regardless of the solution or of the current density. The anodic corrosion rates for each of the specimens pictured in Figs. 9 and 10 are tabulated in Table 1.

From the standpoint of protecting a metal wall against penetration, the information provided by Table 1 is important because it indicates that on the anodic areas remaining when protection is not perfect the rate of penetration remains as high as without any protection. Hence it would be possible to have leaks occurring as early as though no cathodic protection were applied, but the total number of leaks would be less because they occur on a restricted area. In the case of actual corrosion on large surfaces over longer periods of time, however, the anodic and cathodic areas tend to wander from place to place with a consequent evening of the corrosion loss. This is one of the factors that often make cathodic protection more effective in practice than it appears to be in laboratory tests.

P 425.234

A New Way of Supplying Power to a Measuring Line on a Drilling Rig

AN interesting arrangement for supplying power to measuring line reel is shown in the accompanying photographs.

Fig. 1 shows the position of the measuring reel with respect to cathead on the drawworks. A V-belt drives the reel from the cathead when coming out of the hole.

Fig. 2 is a close-up of the measuring line stand. Tension on the V-belt is obtained by operating the crank at the base of the stand, thus moving the reel closer to or farther from the cathead.

Fig. 3 shows the attachment that screws in the open tool joint when depth measurements are taken through the drill pipe. The device is designed so that the measuring line sheave will remain aligned with the reel while the pipe is being rotated.

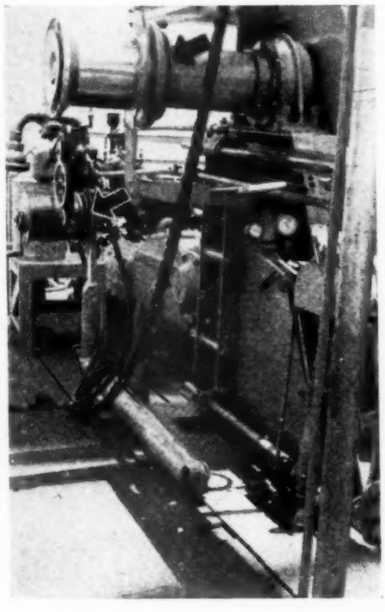


Fig. 1. Arrows point to V-belt sheaves

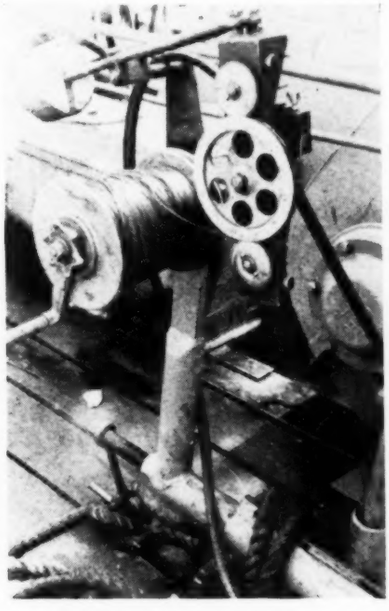


Fig. 2. Close-up of reel stand

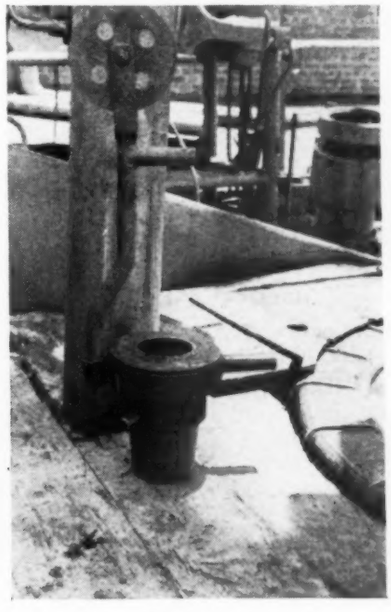


Fig. 3. Attachment whereby wire-line sheave is supported above open drill pipe

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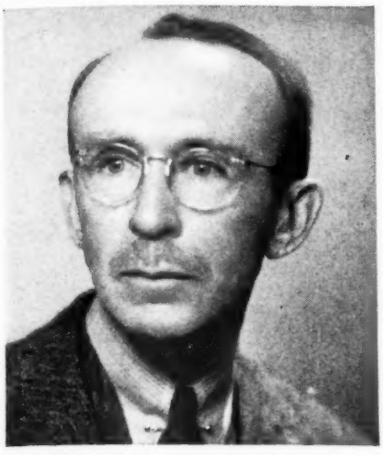
PETROLEUM ENGINEER Exclusive Feature

by R. G. Lovell

Development Engineer, Hancock Oil Company of California



R. G. LOVELL

received his academic training in New York and served several of the larger mining and milling companies of New Mexico, Arizona, and the Republic of Mexico as power engineer and master mechanic from 1908 to 1917, then saw military service in the engineering corps until 1919—Returning from the war he became affiliated with the oil refining industry, first with Standard Oil Company of California as refinery construction engineer and later with a foreign company—Later he was made assistant to the chief engineer of Pan American Petroleum and Transport Company for the construction of their California processing properties—He has been with The Hancock Oil Company of California since that time.

THE rate of discharge when liquids are reduced to atmospheric pressure and when steam is admitted to vessels wherein the pressure is below the initial pressure, is of importance in the refinery.

An accompanying chart (Fig. 1) gives the rate of discharge of water from orifices and from pipes of varying lengths and also includes data on the discharge of water through globe valves. These data have been determined by tests and are dependable.

Examples

Example 1: Suppose that a 1¼-in. globe valve is discharging water to the atmosphere under a discharge gauge pressure of 15 lb. per sq. in. What will be the volume discharged in gal. per min.?

Solution: Enter the upper portion of Fig. 1 at the intersection of the dotted globe valve line with the line drawn for the 1¼-in. pipe or valve. Proceed downward to intersection with the diagonal for 15 lb. per sq. in. gauge pressure, and then continue horizontally to the left where the quantity discharged is given as 84 gal. per min. on the left ordinate. Note that the discharge through 25 ft. of standard 1¼-in. pipe is the same as that through the 1¼-in. globe valve.

Example 2: It is required to determine the quantity of water that will be discharged through 75 ft. of 5-in. standard pipe under a discharge gauge pressure of 50 lb. per sq. in.

Solution: Enter the upper portion of Fig. 1 at the intersection of the horizontal line for 75 ft. of pipe and the line for the 5-in. pipe size. Proceed

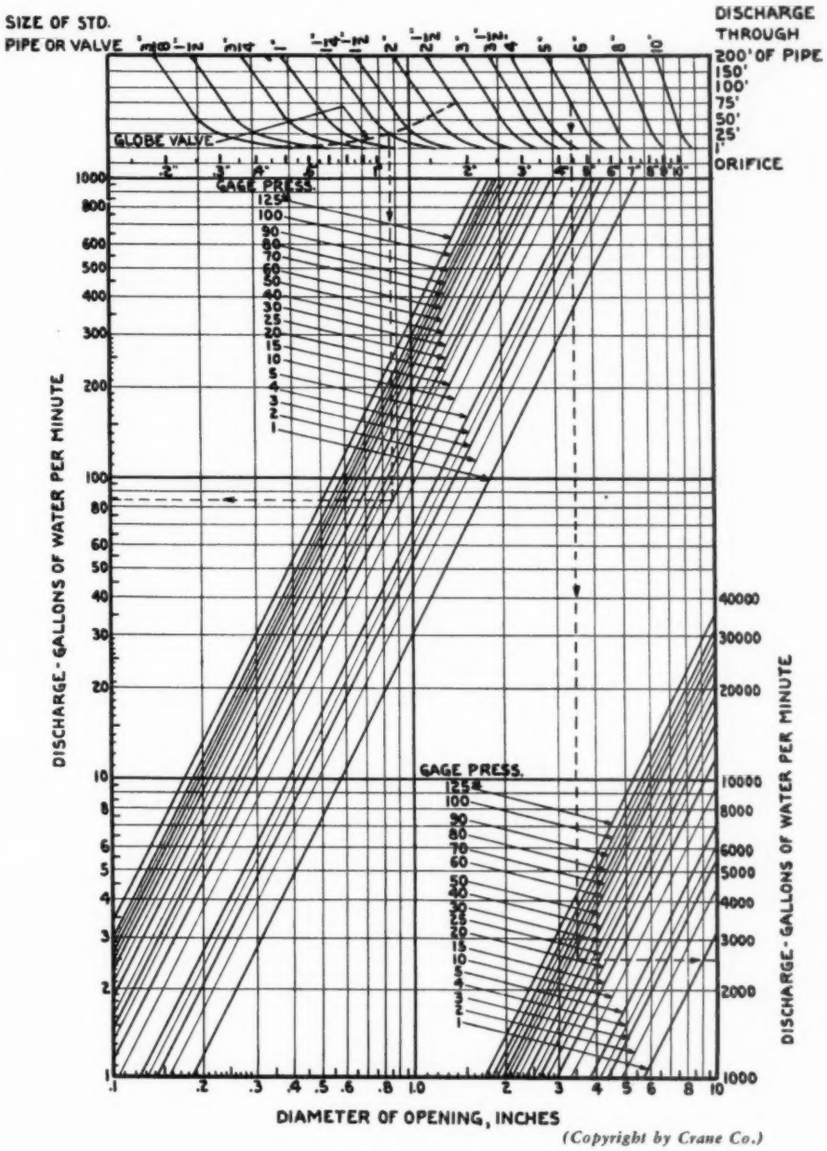


Fig. 1. Discharge of water through pipes, orifices, and valves

(Copyright by Crane Co.)

downward to intersection with the diagonal for 50 lb. per sq. in., and then continue horizontally to the right, where the quantity discharged is given as 2600 gal. per min. on the right ordinate.

Steam Discharge Rate

The flow of steam from a high to a lower pressure increases as the difference in pressure increases to the point at which the external (lower) pressure becomes 58 per cent of the absolute initial pressure. Beyond this point the flow is neither increased nor decreased by a reduction of the external pressure, even to the extent of a perfect vacuum. The lowest pressure for which this statement holds, when steam is discharged into the atmosphere, is 25.37 lb. per sq. in. absolute. For any pressure below this figure the atmospheric pressure, 14.7 lb. per sq. in. (at sea level), is greater than 58 percent of the initial pressure.

At first glance this would seem to be contrary to certain laws of physical science, but it can be accounted for by consideration of the relationships between viscosity, velocity, and pressure drop. As the spread between the high and low pressures becomes greater, the velocity increases, with a consequent increase in the quantity flowing per unit of time. But, as the velocity increases, the effect of viscosity (friction) also increases the value of the friction factor; thus there is a point at which one effect balances the other, and no increase in quantity of flow occurs.

This statement is becoming increasingly pertinent as more consideration is being given to the substantial savings to be made by the generation of steam at high pressure and its use at this high pressure for power purposes, permitting it to expand in the power units to process pressure requirements. If we open a valve in a steam line carrying an absolute pressure of 150 lb. per sq. in. into a vessel wherein the pressure is also 150 lb. per sq. in. absolute there would not, of course, be any flow of steam. If the pressure on the vessel is 140 lb., a definite quantity of steam will pass through the valve and into the chamber and, if the external pressure is 90 lb., a proportionally greater amount of steam will flow. This increase will cease, however, when the pressure in the body has been reduced to 87 lb. per sq. in. absolute (58 percent of 150) and there will be no greater quantity flow, even if the chamber pressure is reduced to zero.

Advantage can be taken of this apparent phenomenon to hold to a definite and constant quantity the amount of steam passing from a high-pressure system to one of lower pressure, such as a tower or still, if the differential does not, at any time, decline below 58 percent.

Fig. 2 shows, in convenient form, the flow of steam through short tubes and orifices and should be used in the following manner:

Fig. 2. Flow of steam through short tubes and orifices

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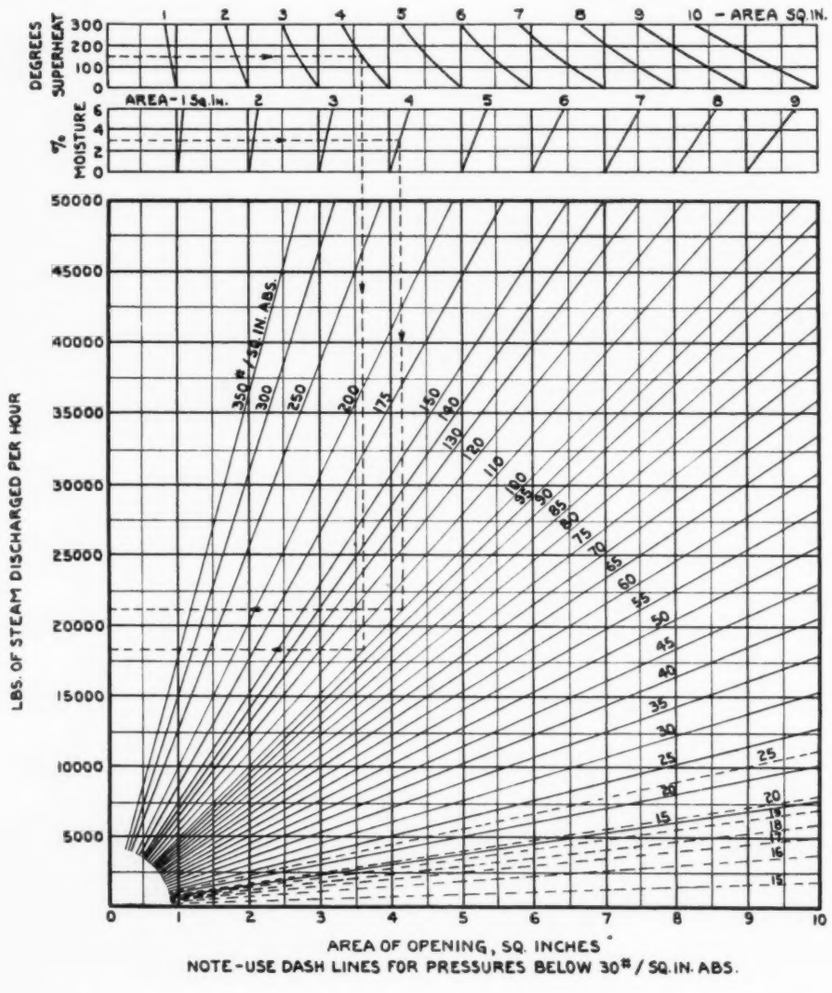

Examples

Example 1: Assume that steam at 100 lb. absolute, with an initial percentage of moisture of 3 percent, is discharging through an orifice with an area of 4 sq. in.

Enter the chart at 3 percent moisture in the upper section and proceed horizontally to the intersection with the diagonal line given for the 4 sq. in. area. Continue to intersection with 100 lb. absolute pressure line, and then to the left horizontally to intersection with the ordinate at 21,250 lb. of steam per hour.

Example 2: Assume that the steam is superheated 150°. Enter the upper left hand section of the chart at 150° superheat and proceed horizontally to intersection with the diagonal line for 4 sq. in. area. Continue down to intersection with the 100 lb. absolute pressure line, and then left horizontally to intersect the ordinate at 18,300 lb. of steam per hour.

Heat Transmission

The question of heat transfer in piping is one of great importance and is one that must be viewed from diametrically opposite angles. It can be one wherein the transfer is desired to be rapid, or it may be desired to hold the transfer to a practical minimum. If steam is to be transported from one place to another through piping, it is desirable, of course, to restrain the heat loss.

Heat Losses From Bare Pipe in Air

Although the determination of heat loss from pipes is generally based on pipes with some type of insulation, the heat loss from the bare pipe must be known with practical accuracy.

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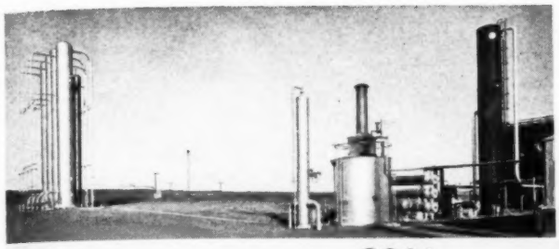
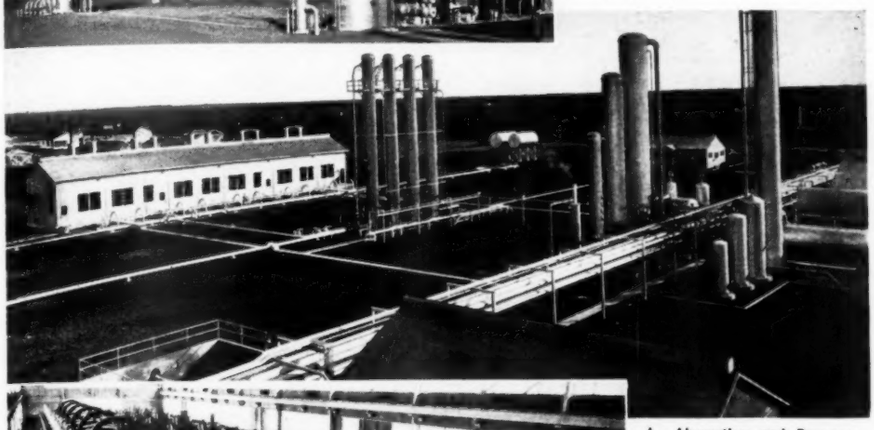


← Dehydration Plant designed for normal capacity of 260 MMCF/24 hrs. at 500 lbs.



↑ Absorption and Pressure Maintenance Plant processing 130 MMCF/24 hrs. at 1,500 lbs.

↑ Main Gas Transmission Line Compressor Station, comprising ten 1,000 H.P. units.

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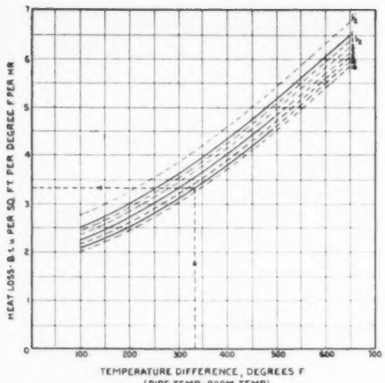


(Courtesy R. H. Heilman and Crane Co.)

Fig. 3. Heat loss from bare iron or steel pipe under still air conditions

Example:

Pipe temp. = 406°F.
Room temp. = 70°F.
Temp. difference = 336°F.
Size of pipe = 10 in.

Procedure:

Enter chart at temperature difference of 336°F. and proceed upward to intersection with curved line for 10-in. pipe. A horizontal line drawn through this point intersects the left-hand ordinate at a heat loss of 3.35 B.t.u. per sq. ft. per °F. per hr.

Fig. 3 shows results of tests that have been made and can be considered as representative of modern practice. The tests were made under still air conditions and a room temperature of 81°F. The loss of heat *from the pipe* depends only on the temperature difference between the pipe surface and the surrounding air, the temperature of the air, the nature of the pipe surface, diameter, position, etc., and is entirely independent of the nature of the steam in the pipe, its velocity, etc. This may seem to be a contradiction of statements previously made regarding total loss of heat in transporting given volumes of steam in stated times. These earlier rules stated that the nature of the steam (normal or superheated) and its velocity, were factors to be considered. The statements are not contradictory because the first ones had to do with *total* loss of heat units from the steam and would, therefore, be affected by specific heat and by the total time of transport. In the latter case we are concerned only with loss of heat from the pipe itself. The subject of velocity of the surrounding air and its effects will be discussed later.

Fig. 4 gives the weight of steam in lb. condensed in bare steam pipes and is based on the data given in Fig. 3.

Example: Suppose a bare 10-in. steel pipe line is transporting saturated steam under a gauge pressure of 250 lb. per sq. in. (264.7 lb. per sq. in. absolute). The temperature of steam at this pressure is 406°, which gives a temperature difference between the pipe and room of approximately 406 minus 70 or 336°.

Entering the chart at a temperature difference of 336° and proceeding upward to the line for 10-in. pipe and thence left to the ordinate, it is noted that the heat loss is approximately 3.35 B.t.u. per sq. ft. per °F. per hour.

If it is desired to determine the total number of B.t.u. lost from the 100 ft. of pipe, the following procedure should be followed:

The number of lineal feet of 10-in. pipe that contains 1 sq. ft. of outer surface is found from tables to be 0.355.

Divide 100 by 0.355 to obtain the number of sq. ft. in the entire line. This answer is 281.69 sq. ft. per 100 lineal ft.

Multiply 281.69 by 3.55 to obtain the number of B.t.u. lost per degree. This answer is 943.66 B.t.u. per hr. per °F.

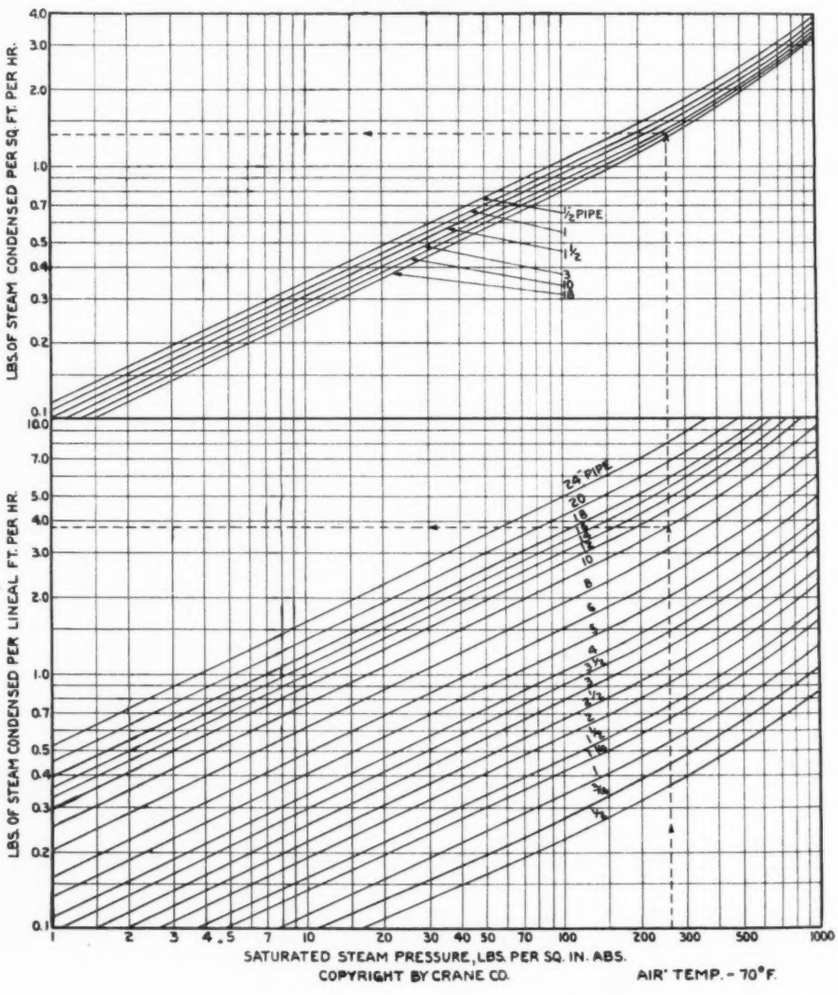
If it is desired to determine the pounds of steam condensed per sq. ft. of pipe surface per hour, enter the chart at 264.7 lb. per sq. in. absolute on the abscissa and proceed upward to the line for 10-in. pipe in the upper section of the chart; proceed to the left from this point and read the value 1.37 lb. of steam condensed per sq. ft. per hour.

On the other hand, if it is desired to determine the pounds of steam condensed per lineal foot of pipe surface per hour, enter the chart at 264.7 lb. per sq. in. absolute on the abscissa and proceed upward to the line for 10-in. pipe in the lower section of the chart; proceed to the left from this point and read the value 3.8 lb. of steam condensed per lineal ft. per hour.

Acknowledgment

Acknowledgment is made to Crane Co., Chicago, Illinois, for permission to reproduce the drawings in this article. These appear in Crane Co.'s publication, "Engineering Data on Flow of Fluids in Pipes."

Fig. 4. Heat loss from bare iron and steel pipe in air — lb. of steam condensed per sq. ft. per hr.


LBS. OF STEAM CONDENSED PER SQ. FT. PER HR.
LBS. OF STEAM CONDENSED PER LINEAL FT. PER HR.
½ PIPE
1½
24" PIPE
SATURATED STEAM PRESSURE, LBS. PER SQ. IN. ABS.
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AIR TEMP. - 70°F.

Mathematical Analysis of Whipstock Setting

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☆ Principles of geometry may be applied to determine exact setting of whipstock to reach the desired point

by Arthur W. McCray

Instructor, Petroleum and Natural Gas Engineering, The Pennsylvania State College

ARTHUR W. McCRAY

is an instructor in Petroleum and Natural Gas Engineering at The Pennsylvania State College —Before entering college he worked as roustabout and pumper in the Pennsylvania oil fields—Worked two years in the plant of the Pennzoil Refining Company—Spent two years in oil-field development work, both around drilling rigs and air-gas repressuring—In 1937 he entered The Pennsylvania State College and received a bachelor's degree in June, 1940—In the fall of 1940 he was employed as an instructor in petroleum engineering.

THE correct solution of a directional or objective drilling problem, from an engineering viewpoint, must be based on these principles: (1) The well must reach the desired objective; (2) for economical drilling, the least possible number of whipstock settings must be used; (3) furthermore, the amount of curvature in the well bore must be kept at a minimum in order to obtain maximum economy and ease of operation of the well during production. The last two principles go hand in hand; with any given whipstock angle, satisfying the conditions of one satisfies the conditions of the other.

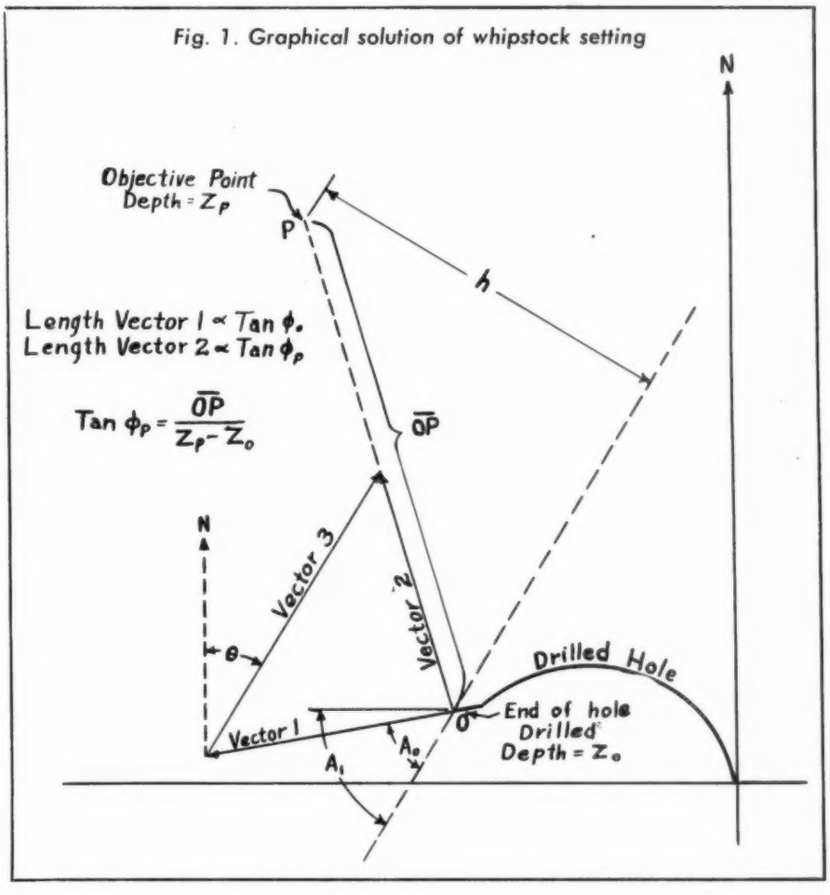
Most wells are drilled to reach a definite point, whether it be under the derrick floor or a point having several hundred feet horizontal displacement from the top of the hole. In the problem considered here, a well has been drilled part way down and a survey of the hole has been made. Information is then available giving the location of the bottom of the hole drilled (or some take-off point above bottom may be selected), and the horizontal direction and inclination from the vertical at that point will also be given by the survey. Knowing this, and the position of the objective point, the problem consists of calculating the required whipstock settings.

Principles of Solution

In order to keep the total curvature induced into the well bore at a minimum, the future course of the well from the take-off point, or bottom, must be kept within a plane. It is a principle of solid geometry that a line and a point in space determine a plane. In the present case, the end section of the well with its given direction and vertical dip is the line, and the desired objective is the point. In general, the plane so determined will be neither horizontal nor vertical, but will be a skew plane.

The progress of a well being drilled toward a point in space can be shown by drawing a line on a sheet of paper, and ahead of the line and off to one side placing a point. In this case, the plane existed first; otherwise, conditions are the same as existed when the plane was passed through the end section of the well and the objective point. In order to make the line reach the point, it may be extended, proceeding with a given small angle of deviation

Fig. 1. Graphical solution of whipstock setting

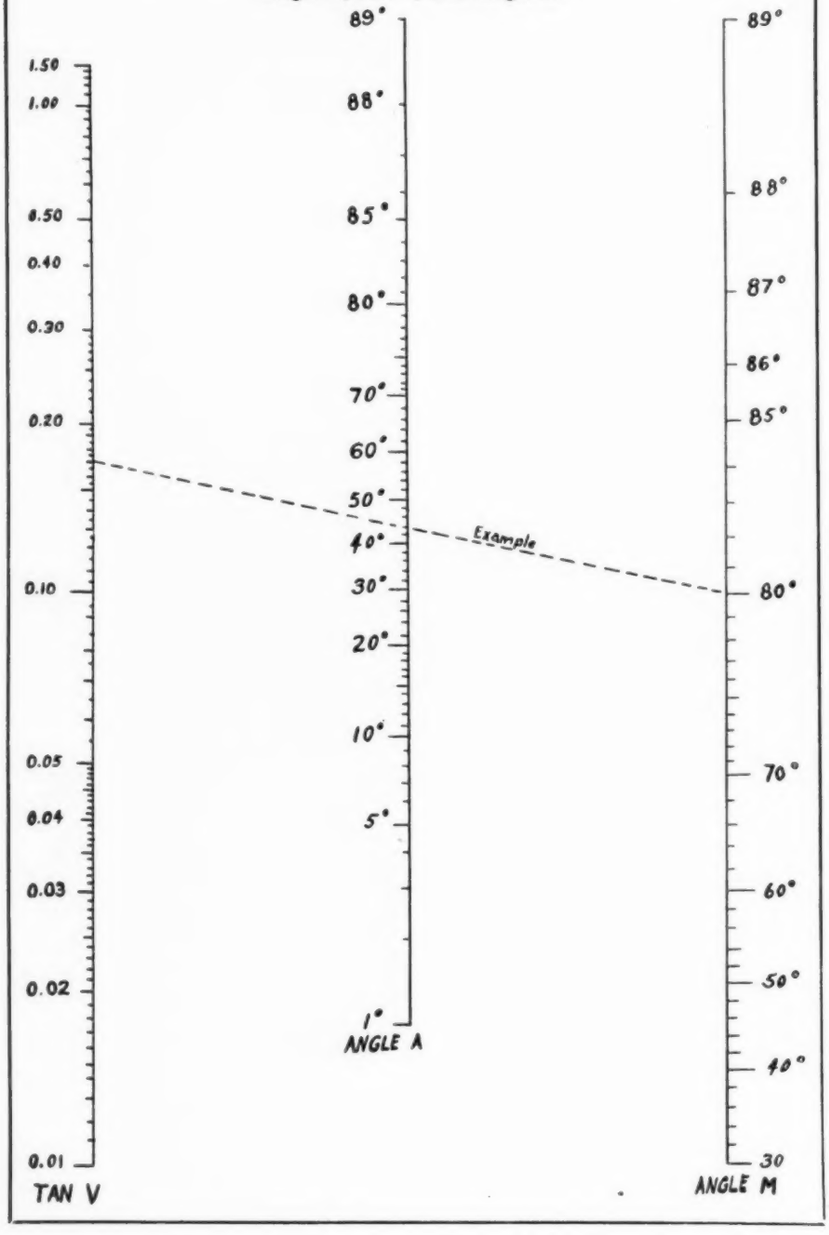


from its original course. The extended line will most closely approach the point if it is extended on the paper, not pointing up from the surface of the paper. Similarly, if the end of the line and the point are connected by a series of line segments all joined to each other at a small angle of departure, the total number of line segments, or the total curvature, will be least when all segments lie in one plane; that is, all lie on the paper. The limiting case appears when the point lies directly in the path of the line and no curvature is induced.

Directional Setting of Whipstock

The directional setting of a whipstock is controlled by a reference mark on the drill pipe above the whipstock. In the case where the drill pipe survey method is used to orient the whipstock, the reference mark is carried up the pipe in steps by the transits. In the case where magnets are placed within a section of drill pipe just above the whipstock, the mark is preserved in the bottom of the string of pipe. In either case, the direction in which the reference mark points away from the center of the hole is the direction that is measured. If the well bore lies within the skew plane, and if the whipstock dog-leg lies within the plane, it follows that the reference mark itself will be in the skew plane; that is, a line through the center of the drill pipe passing through the reference mark will lie in the skew plane. Therefore, so long as the direction of the whipstock is measured in a horizontal plane, with the measuring instruments kept level, the whipstock should be pointed along the line in which the skew plane cuts through any horizontal surface. This line is known mathematically as a horizontal trace line.

Fig. 2. Alignment chart showing relationship between Angle A, Tan V, and Angle M



Formula and Vector Solution

A practical method giving the correct directional setting of a whipstock for reaching a desired point in space can be based on exact mathematical principles. Where any two lines join and thus determine a plane, the algebraic expression giving the direction in which the generated plane cuts any horizontal surface is:

$$\text{Tan } \theta = \frac{\text{Tan } \phi_1 \sin \alpha_1 - \text{Tan } \phi_2 \sin \alpha_2}{\text{Tan } \phi_1 \cos \alpha_1 - \text{Tan } \phi_2 \cos \alpha_2}$$

in which:

θ = direction angle in which skew plane cuts the horizontal.

ϕ = angle of deviation from the vertical.

α = direction angle of sections of the hole.

Subscripts 1 and 2 refer to adjacent sections of the hole.

A vector solution can be developed that gives exactly the same results as the above formula. The vectors point in the direction in which the hole is drifting, and the length of the vectors must be proportional to the tangents of the respective angles of deviation from the vertical of the two sections of hole. These two originate at the same point, and a vector line lying across their ends has a direction angle θ. It, therefore, gives the horizontal trace line direction of the skew plane; and it gives immediately the direction in which to set the whipstock in order to continue the hole in that same plane.

Practical Solution

Fig. 1 shows the practical solution of a whipstock setting problem. The solution is worked out on a horizontal projection map of the well. Vector 1 lies in the direction assumed by the end of the drilled hole, and the length of vector 1 is proportional to the tangent of the vertical angle of the end section of the drilled hole. Vector 2 points directly from the end of the drilled hole toward the objective point. The length of vector 2 is proportional to the tangent or slope of an imaginary line drawn from the end of the drilled hole down to the objective point. The vertical slope of this line is equal to the horizontal displacement between the end of the drilled hole and the objective point (distance OP, which

PETROLEUM ENGINEER EDITION

BAASH-ROSS News

BAASH-ROSS TOOL COMPANY, LOS ANGELES, HOUSTON, NEW YORK

A BULLETIN COVERING NEWS OF EQUIPMENT AND OPERATIONS IN THE PETROLEUM INDUSTRY

183,000 FT. SERVICE CHECK REVEALS REMARKABLE LIFE OF B-R KELLY BUSHINGS

Inside Story of How Bushing Parts "Miked" After 34 *Miles* of Hole!

There are two important things you want to know about a kelly bushing . . .

(1) What are its operating advantages?

(2) How does it stand up under month after month of punishing service?

You operators who are now using *Baash-Ross Type 2R Roller Kelly Bushings* already *know* the answer to that first question. You know from your own experience that this Bushing stands head and shoulders above the field for smooth, uniform kelly feed . . . for friction-free weight control . . . for more efficient operation at ALL rotational speeds under ALL types of field conditions.

But if you are one who has not yet tried this Bushing, there's only one way

you'll ever find out the tremendous difference it makes in your drilling control and that is to try one out on YOUR own rig, under *your* particular drilling operations. Give it any test you like. Turn it at any speed . . . feed the weight slow or fast, light or heavy . . . and convince yourself that every word we say about its outstanding operating advantages is solid FACT.

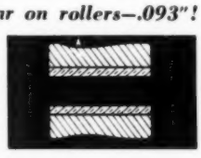
But what about the second question—How does it stand up? Well, here's the answer to that—*an actual case study* that gives you some idea of the unusually *long, trouble-free service* you'll get from a Baash-Ross Roller Kelly Bushing. This particular bushing was bought by an operator* who used it on well after well of a punishing drilling campaign. When it had finally chalked up a total of 183,000 feet of hole, he sent it in for servicing. And while it was in, Baash-Ross engineers checked it over part by part to see what wear the 183,000 feet had caused.

Baash-Ross Kelly Bushings are fully described in Bulletin 4B, mailed on request. *Write for your copy now.*

*Name gladly supplied to those interested.

▶ First, think what that amount of hole means. How deep is your average well? 5000 feet? Then this bushing drilled the equivalent of more than *thirty-six* such wells before it came in for service. That alone is a remarkable record. But even more remarkable is the comparatively small amount of wear found on the various parts when the bushing was checked. For example, here are some of the important findings . . .

Maximum wear on rollers—.093"!

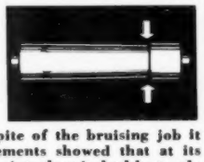


As might be expected, the greatest roller wear occurred on the "driving" area—the part where maximum pressure occurs when driving the kelly (see sketch). But even here—at the point "A" where the wear was greatest—only 93 *thousandths* of an inch of surface was lost. That's a reduction of just 2.96% from the original diameter of the roller!

Max. Bushing Sleeve wear—.026"!

On the replaceable bushing which fits inside the roller, the maximum wear occurred at the point indicated in sketch, where .026" of surface was lost. That's a loss of only 1.7% from the original diameter!

Maximum wear on Pin—.015"!



The pin, which is anchored into bearings at each end, is the member which transmits the driving torque to the roller and thence to the kelly. In spite of the bruising job it must do, measurements showed that at its greatest wearing point, the pin had lost only 15 *thousandths* of an inch surface. That's a maximum loss of only 1% of the original pin diameter!

Look at those figures again and then remember that the roller assembly is the part that takes the punishment of sudden twists and impacts between kelly and bushing . . . the part that *drives* the kelly in one axis yet must roll effortlessly in another to permit instant kelly feed through the bushing . . . the part that is working *hardest* every minute you're drilling. Yet, after drilling more than *34 miles* of hole, the various parts of this assembly showed—*at the most*—only the small amounts of wear given above.

▶ The story was essentially the same on other parts of the Bushing. A maximum of $\frac{1}{16}$" (and an *average* of only $\frac{1}{64}$") wear, on the Cages that hold the Roller assemblies in place—figures that represent a very small change in the over-all dimensions of the Cage . . . a little over $\frac{1}{8}$" wear in the corners of the Body where it fits into the master bushing, the point that probably takes a worse beating than any other . . . are further examples of the way this Bushing stood up under the gruelling wear of 183,000 feet of service. And this is typical of the longer life, the exceptional strength, the all-around operating efficiency built into *every* Baash-Ross Kelly Bushing.

REMEMBER—you save *two* ways with a Baash-Ross Roller Bushing. You get smoother, far more accurate kelly feed . . . and you get longer, more dollar-for-dollar service. So check into the Type 2R Roller Kelly Bushing NOW for your next Kelly Bushing purchase. Either the 2RS for *square* kellys or the 2RH for *hex* kellys will give you the most Bushing your money can possibly buy!

Your nearest Baash-Ross representative has all the details. See him today. Or write direct for full information!

ON THE LOOKOUT

PROPER ENGINE MAINTENANCE **increases in importance as the spotlight centers more and more on spark plug drilling rigs. Recent development for heavy duty oil, gas or Diesel engines is an oil filter which magnetically extracts all ferrous material from the crankcase oil. Is said to remove particles as small as 1/25,000 of an inch . . . has no cartridge to change . . . can be quickly cleaned . . . costs nothing to operate. (No. B-101)**

BAASH-ROSS

A NEW "WELDRULE" **that operates like a slide rule, saves much time in estimating electrode requirements on pipeline jobs, etc. Reads directly length of welded joints obtainable per 100 lbs. of electrode, also pounds of weld metal deposited per 100 lbs. of electrode. Covers 11 different sizes and types of joints, 22 different sizes and types of electrodes in both 14" and 18" lengths. A real timesaver for anyone using or supervising arc welding in the oil industry . . . and it's free! (B-102)**

BAASH-ROSS

ACCORDING TO A RECENT REPORT, **the incorporation of ordinary cornstarch into drilling mud greatly reduces loss of water into drilled formation, and materially improves the characteristics of the cake. In a typical test, a 73.7 lb./cu. ft. mud with water loss of 49.8 milliliters in two hours (at 200° F.—2000 lbs. pressure) showed a water loss of only 11.5 milliliters under the same conditions after addition of only 2% cornstarch. (B-103)**

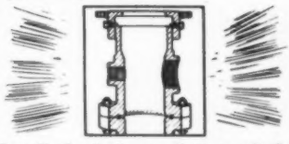
Further information on items that interest you is available by sending your name, address and key number on a postcard or letterhead.

HERE'S THE SPEED YOU WANT WHEN BLOWOUTS THREATEN

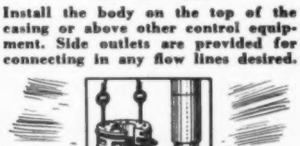
When a blowout threatens, there's one thing you want—a simple, positive, quick-acting packer you can set *right now.*

And that's exactly what you get in the Baash-Ross Blowout Preventer. It's simple. It's always ready for instant use. And because the packing unit is in place only when a pack-off is required, there's no danger of damaging the rubbers or finding them worn-out when an emergency arises. What's more, *it's the only Preventer on the market that seals off tighter as the pressure increases!*

Here's all you do . . .

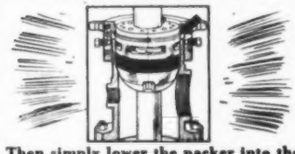


Install the body on the top of the casing or above other control equipment. Side outlets are provided for connecting in any flow lines desired.



Hang the packing assembly from a line in the derrick, ready for instant use. Note that the preventer body is empty under all normal operations.

When a blowout threatens, just swing the packer around the pipe or kelly. It *automatically* locks into position.



Then simply lower the packer into the body where the lock rings (arrow) automatically lock it firmly in place.

It's simple, fast, fool-proof. Once the packer is locked in place you can make an instant seal by setting the weight of the string down on the packer . . . or, if more convenient, by pulling a collar up against the bottom of the packer. For a *permanent* seal, simply tighten the threaded ring down against the packer assembly. Then the pipe can be rotated or moved up and down between couplings without affecting the seal.

▶ Ask your nearest Baash-Ross representative for details on this Blowout Preventer. It's available to fit all standard drilling set-ups!

can be scaled from the map) divided by the difference in vertical depth between the two points (designated on the map as $Z_p - Z_o$). Vector 3, going from the end of vector 1 to the end of vector 2, points in the direction in which the whipstock should be set.

A numerical example may make the solution clearer. Suppose that the distance on the horizontal map between the end of the drilled hole and the objective point is 300 ft. Let the depth to the objective point be 4000 ft. and the vertical depth to the whipstock be 2350 ft.; the difference is 1650 ft. Then, 300 ft. divided by 1650 ft. equal 0.182. The deviation of the hole from the vertical at 2350 ft. is 10°, and the tangent of 10° is 0.176. Multiply both by ten, and make vector 1 with a length of 1.76 in. and vector 2 with a length of 1.82 in. Then vector 3 points N 32° E, and this is the direction in which to point the whipstock.

Forecasting Course of Hole

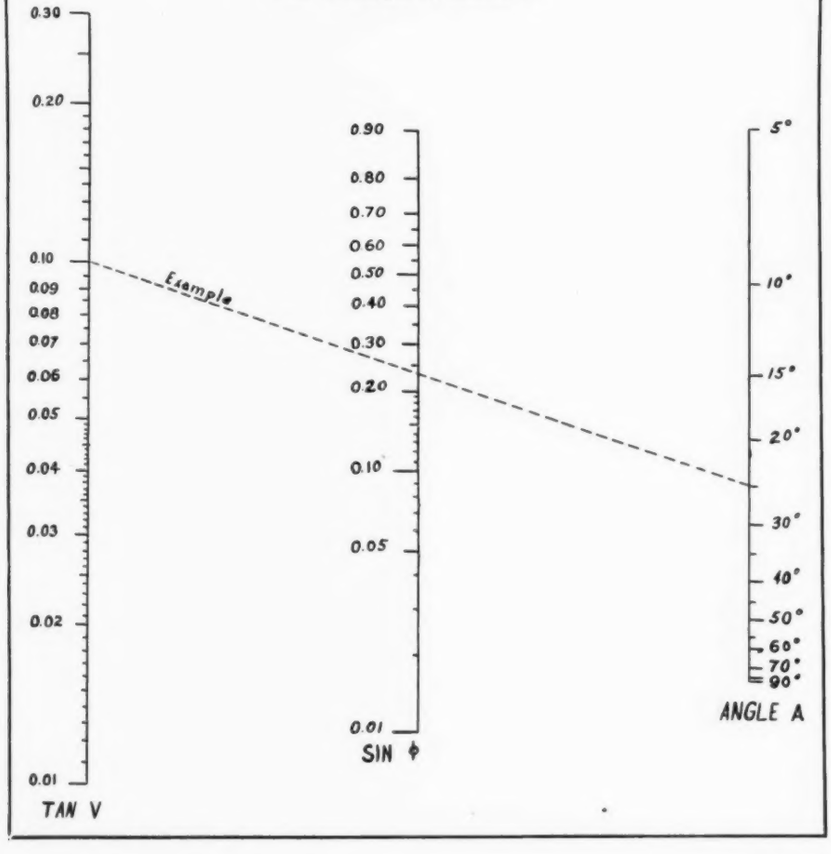
Although it cannot be expected that actual results in deflecting a hole will follow exact mathematical calculations, nevertheless it may be desirable to predict the number of settings required from a particular point in the well bore. In using the solution previously given, it has been assumed that slight deviations will occur in the whipstocking, and the original solution should be repeated for each setting. In laying out the future course of a hole, however, a single definite skew plane is established and used throughout. Accordingly, the first step consists of carrying out the vector solution. This establishes the direction in which the skew plane cuts a horizontal surface.

It will further be necessary to establish the vertical slope of the skew plane, which contains the future course of the well. This also is done on the horizontal map of the well. A dotted line is drawn on the map parallel to vector 3 and passing through the point where the first whipstock is set. The perpendicular distance from the objective point to this line must be scaled on the map; and this is the distance h on Fig. 1. Dividing this distance h by the difference in vertical depth between the objective point and the first deflection point gives the vertical slope of the skew plane, which shall be known as tan V.

A definite relationship exists between the horizontal angle showing on the map as angle A and an angle M lying in the skew plane and tan V. This relationship is:

$$\tan A = \tan M \sin V.$$

Fig. 3. Alignment chart showing relationship between Tan V, Angle A, and Sin ϕ



A = horizontal angle between the trace of the skew plane and a section of the hole lying in the plane.

V = vertical angle of the skew plane.

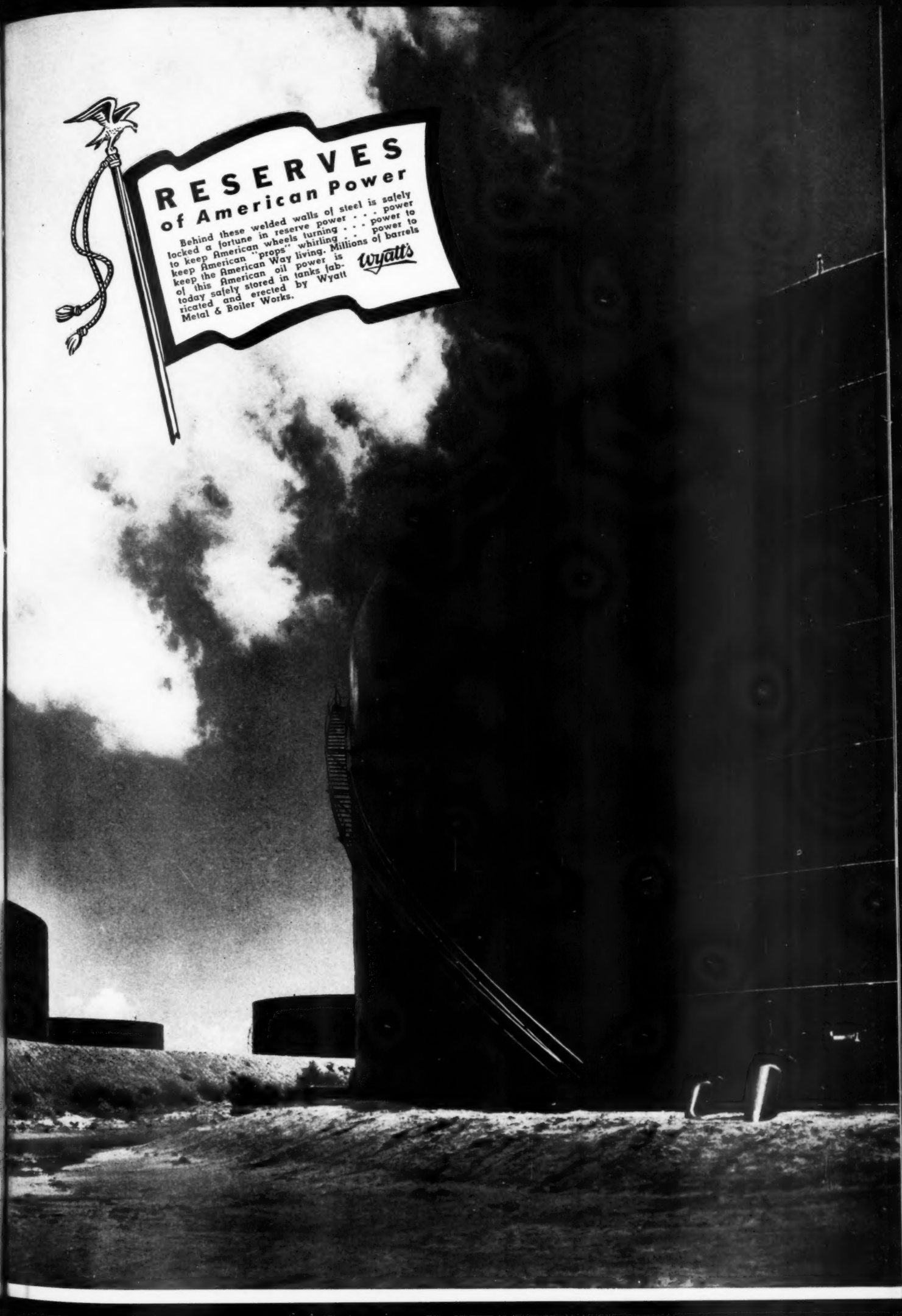
M = angle within the skew plane between the horizontal trace and the section of hole.

It should be noted that the angle M lies in the skew plane. Therefore, the whipstock angle can be added directly to the angle M. In working through such a problem, the alignment chart in Fig. 2 can be used. Tan V remains constant throughout. Let A_o be the measured angle between the trace line and the last section of the hole. On Fig. 2, pass a straight line through tan V and A_o to find a corresponding angle M_o. Add the whipstock angle to M_o to give a value M_1, and work back on the chart to find the corresponding angle A_1. Repeat this as many times as required to find the angles A, which give the horizontal directions of the various sections of the hole.

There remains another source of information about the new course of the well. On Fig. 3, connecting tan V and any angle A with a line gives the numercial value of sin ϕ. This is the portion of the length of hole drilled that will appear on a horizontal map. For example, where sin ϕ equals 0.10 and 100 ft. of hole is drilled between deflection points, that section of the hole should be drawn 10 ft. long on the horizontal map. Thus both the lengths and directions of the theoretical sections of the hole can be determined and plotted on the horizontal map. When any line representing a section of the hole passes very near the objective point, a sufficient number of deflections is indicated.

Conclusion

A vector solution is shown in Fig. 1 that gives the theoretically correct direction in which to point a whipstock in order most economically to reach a definite objective point. This solution should be repeated for each setting in order automatically to correct for deviations from the ideal deflection that will occur in actual practice. Fig. 2 is an alignment chart that can be used to give the direction a new section of hole should assume, and Fig. 3 is an alignment chart giving the fractional length of a section of drilled hole that will appear on a horizontal map. The two alignment charts can be used for plotting possible future courses of the hole. In this manner an economic study can be made showing the best point to take-off from the original course of a well in order to reach some new objective.


RESERVES
of American Power
Behind these welded walls of steel is safely locked a fortune in reserve power . . . power to keep American "props" whirling . . . power to keep the American Way living. Millions of barrels of this American oil power is today safely stored in tanks fabricated and erected by Wyatt Metal & Boiler Works.
Wyatt's

Computing Gas Flow in Pipe Lines

PETROLEUM ENGINEER Exclusive Feature

PART 2

by P. McDonald Biddison

Consulting Engineer

A photograph and biographical sketch of the writer can be found on page 51 of the August issue of The Petroleum Engineer in connection with Part 1 of this article.

DREW AND GENEREAUX, as a result of experiments on commercial pipe proposed the equation:

$$\frac{1}{\sqrt{f}} = 3.2 \text{ Log } (R\sqrt{f}) + 1.2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (32)$$

This equation does not seem to represent the conditions of flow in large commercial lines. It is plotted on Fig. 1 as Curve B for comparison with Curve A representing equation (31). Data on the Cities Service 20-in. Pampa-Wichita line taken from a paper by Benjamin Miller[7] is plotted on this sheet together with three tests by C. H. M. Burnham on Panhandle Eastern's 24-in. line on sections known to be clean and with the tests given in Table 7 of U. S. Bureau of Mines' Monograph 6.[1] Of the latter tests only lines 1, 2, 5, 12, 16, and 29 (indicated by being circled on Fig. 1) have been used, the others being disregarded for reasons cited in the monograph (pressure variation, pulsation, water, slope, bends, etc.). Tests on two 10-in. lines laid as oil lines are rejected because the writer saw the lines under construction and they could not have been clean. The selected data seem to justify Curve C of Fig. 1. Its equation is:

$$\frac{1}{\sqrt{f}} = 3.62 \text{ Log } (R\sqrt{f}) - 0.10 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (33)$$

The determination of the friction factor from Fig. 1 (or from Table I from which the curves are plotted) requires some discretion. Curve "C" or equation (33) are not suggested as a permanent locus of f but as one to use until a better one is found. Its relationship to A does not produce a constant value of E but one which decreases as R increases. The efficiency at R = 10,000,000 (Log R = 7.0) indicated by Curves A and C of Fig. 1 is $\frac{20.5}{22.2}$ or 92.4 percent. "C" intersects "B" at about R = 13,891. For lines not known to be clean or for small lines, say 6 in. and smaller, or for Reynolds numbers below 100,000, Curve B is the safer one to use.

(Recent data from J. A. Clark of Hope Natural Gas Company on tests of that company's high-pressure 12-in. line, 94.89 miles in length, at values of R from about 2,500,000 to about 7,750,000 and pressures from 483 to 987 lb. per sq. in. gauge, gives values of $\frac{1}{\sqrt{f}}$ that closely approximate Curve B. The friction factors for the Cornwell-Maxwell section, 71.28 miles, determined separately, however, are appreciably higher at same Reynolds numbers than for the full length. If time permitted analysis of the 23.61 miles separately, a reason for the difference and for the resultant overall high values of f might be found that would make the results more nearly in line with Curve C. Such reason might reasonally be found in difference in bends per mile on the two sections or in matters of corrrection for elevation changes.)

The determination of the friction factor from Fig. 1 or equations (31), (32), or (33) is possible only if the rate of flow is known, as the rate of flow is requisite for determination of the Reynolds number, as discussed later. For solution of that class of problems in which the pressure conditions are known and the quantity of flow is to be determined it is essential that the friction factor be expressed in terms independent of the value of Q or R. This may be done by combining the general equation discussed earlier with equations (31), (32), and (33).

$$Q = 38.7744 \times \frac{T_0}{P_0} \times \sqrt{d^5 \times \frac{P_1^2 - P_2^2}{GTLf}} \quad . \quad . \quad . \quad (1)$$

Substituting the value of $\frac{1}{\sqrt{f}}$ from equation (28):

$$Q = E \times 38.7744 \times \frac{T_0}{P_0} \times \sqrt{d^5 \times \frac{P_1^2 - P_2^2}{GTLf_a}} \quad . \quad (34)$$

$$\sqrt{f_a} = \frac{E \times 38.7744 \times T_0}{Q \times P_0} \times \sqrt{d^5 \times \frac{P_1^2 - P_2^2}{GTL}} \quad . \quad (35)$$

Substitute equation (35) in right hand member of equation (31):

$$\frac{1}{\sqrt{f_a}} = 4 \text{ Log } R\left(\frac{E \times 38.7744 \times T_0}{Q \times P_0} \times \sqrt{d^5 \times \frac{P_1^2 - P_2^2}{GTL}}\right) - 0.4 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (36)$$

From equation (58):

$$R = \frac{Q \times P_0 \times G}{d \times T_0 \times Z} \times \frac{477.3597}{10^6} \quad . \quad . \quad . \quad . \quad (59)$$

Substituting in equation (36):

$$\frac{1}{\sqrt{f_a}} = 4 \text{ Log}\left(\frac{Q \times P_0 \times G \times 477.3597}{d \times T_0 \times Z \times 10^6} \times \frac{E \times 38.7744 \times T_0}{Q \times P_0} \times \sqrt{d^5 \times \frac{P_1^2 - P_2^2}{GTL}}\right) - 0.4 \quad . \quad (37)$$

$$= 4 \text{ Log} \frac{d^{1.5} \times G^{0.5} \times E \times 18509.34}{Z \times 10^6} \times \sqrt{\frac{P_1^2 - P_2^2}{TL}}\Bigg) - 0.4 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (38)$$

$$\frac{1}{\sqrt{f_a}} = 2 \text{ Log}\left(\frac{d^3 \times G \times E^2 \times 342.60 \times (P_1^2 - P_2^2)}{Z^2 \times 10^6 \times T \times L}\right) - 0.4 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (39)$$

0.4 = 2 Log 1.5849, hence:

$$\frac{1}{\sqrt{f_a}} = 2 \text{ Log}\left(\frac{342.60 \times d^3 \times G \times E^2 \times (P_1^2 - P_2^2)}{1.5849 \times Z^2 \times T \times L \times 10^6}\right)$$

$$= 2 \text{ Log } \frac{216.165 \times d^3 \times G \times E^2 \times (P_1^2 - P_2^2)}{Z^2 \times T \times L \times 10^6}$$

If $Z = \frac{7}{10^6}$

$$\frac{1}{\sqrt{f_a}} = 2 \text{ Log} \frac{4.4115 \times d^3 \times G \times E^2 \times (P_1^2 - P_2^2) \times 10^6}{T \times L} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (41)$$

Equation (40) is a rearrangement of the equation of Benjamin Miller[7] with a slight difference in the constant.

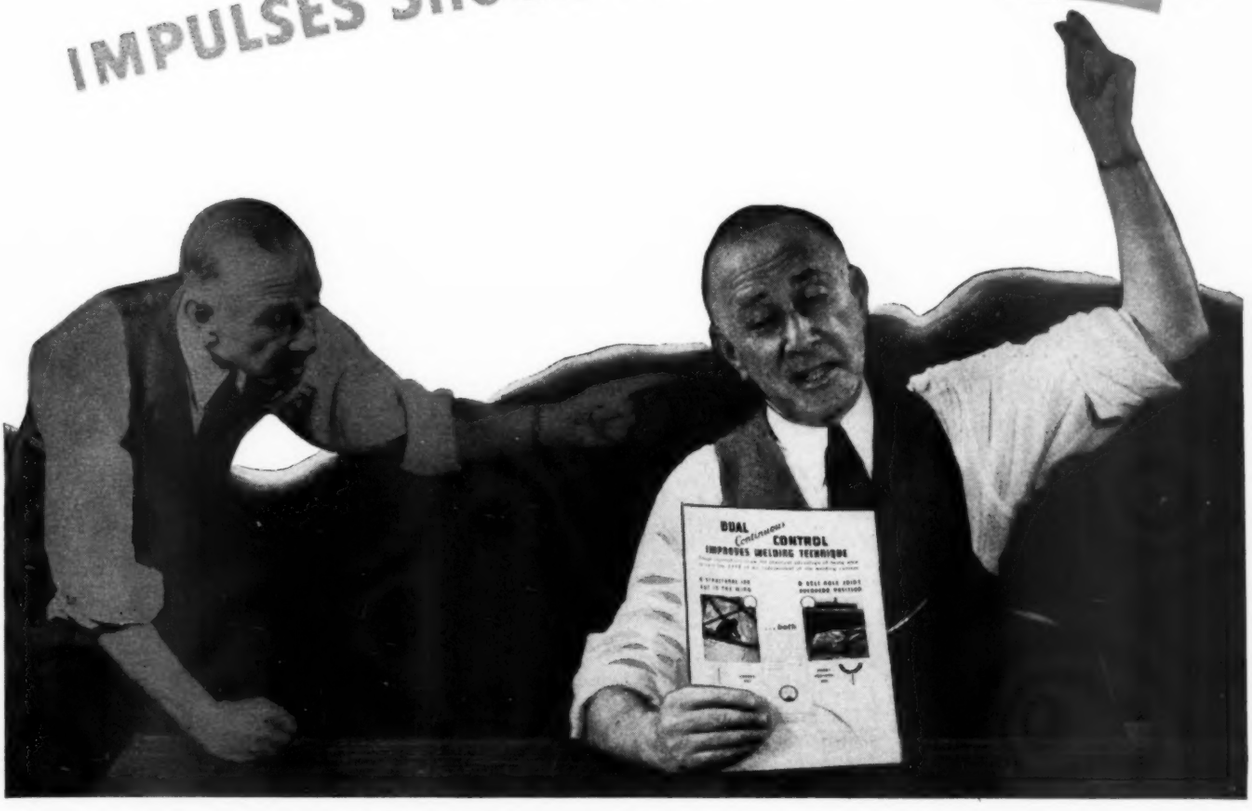
Similarly as for equation (35) we derive from equation (1):

$$\sqrt{f} = \frac{38.7744 \times T_0}{Q \times P_0} \times \sqrt{d^5 \times \frac{P_1^2 - P_2^2}{GTL}} \quad . \quad . \quad (42)$$

This may be substituted in equation (32) (Drew and Genereaux equation):

$$\frac{1}{\sqrt{f}} = 3.2 \text{ Log } R\left(\frac{38.7744 \times T_0}{Q \times P_0} \times \sqrt{d^5 \times \frac{P_1^2 - P_2^2}{GTL}}\right) + 1.2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (43)$$

IMPULSES SHOULD BE TAKEN HOT!



ALTER EGO: Literally, "one's other self"—the still, small voice that questions, inspires, and corrects our conscious action.

We've got to buy a welder. That's settled; but I blow hot and cold on all of them. They don't seem to differ materially.

ALTER EGO: There you are! When your mind is in a state of uncertainty—then the tiniest impulse directs it to either side.

Then what BIG impulse will set my mind in a sure channel?

ALTER EGO: Forget welders. THINK ABOUT WHAT YOU WANT A WELDER TO DO FOR YOU.

I DO know we must get faster production, better welds and lower costs on all *jobs.*

ALTER EGO: Well, that in itself says you MUST have DUAL CONTINUOUS CONTROL so the operator can adjust for the right TYPE and SIZE of arc to suit the job—to suit the position of the work—to suit his particular technique—to suit the type of joint—to suit the kind of metal. He gets these with the easy, fine adjustment of his DUAL CONTINUOUS CONTROL—just as simply as he gets the right station and the right volume on his radio.

• •

LINCOLN SUGGESTS: To warm up to the *right* welding machine, base your analysis on *performance values.* Find out which machine, under *all* conditions and with *all* types of work, will produce the *highest quality welds* at *lowest cost.* A small advantage in performance often can save hundreds of dollars yearly—soon paying for the welder. Bulletin 412 will stimulate your impulses.

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LINCOLN "SHIELD-ARC" WELDING THE LINCOLN ELECTRIC COMPANY Cleveland, Ohio

Largest Manufacturers of Arc Welding Equipment in the World

Substituting the value of R from equation (58):

$$\frac{1}{\sqrt{f}} = 3.2 \operatorname{Log}\left(\frac{Q \times P_0 \times G \times 477.3597}{d \times T_0 \times Z \times 10^6} \times \frac{38.7744 \times T_0}{Q \times P_0} \times \sqrt{d^5 \times \frac{P_1^2 - P_2^2}{GTL}}\right) + 1.2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (44)$$

$$= 3.2 \operatorname{Log}\left(\frac{d^{1.5} \times G^{0.5} \times 18509.34}{Z \times 10^6} \times \sqrt{\frac{P_1^2 - P_2^2}{TL}}\right) + 1.2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (45)$$

$$\frac{1}{\sqrt{f}} = 1.6 \operatorname{Log}\left(\frac{d^3 \times G \times 342.60 \times (P_1^2 - P_2^2)}{Z^2 \times 10^6 \times T \times L}\right) + 1.2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (46)$$

$1.2 = 1.6 \operatorname{Log} 5.6234$, hence:

$$\frac{1}{\sqrt{f}} = 1.6 \operatorname{Log}\left(\frac{d^3 \times G \times 1926.58 \times (P_1^2 - P_2^2)}{Z^2 \times 10^6 \times T \times L}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (47)$$

If $Z = \frac{7}{10^6}$

$$\frac{1}{\sqrt{f}} = 1.6 \operatorname{Log} \frac{39.318 \times d^3 \times G \times (P_1^2 - P_2^2) \times 10^6}{T \times L} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (48)$$

For the suggested equation (33):

$$\frac{1}{\sqrt{f}} = 3.62 \operatorname{Log} R\left(\frac{38.7744 \times T_0}{Q \times P_0} \times \sqrt{d^5 \times \frac{P_1^2 - P_2^2}{GTL}}\right) - 0.10 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (49)$$

Substituting the value of R from equation (58):

$$\frac{1}{\sqrt{f}} = 3.62 \operatorname{Log}\left(\frac{Q \times P_0 \times G \times 477.3597}{d \times T_0 \times Z \times 10^6} \times \frac{38.7744 \times T_0}{Q \times P_0} \times \sqrt{d^5 \times \frac{P_1^2 - P_2^2}{GTL}}\right) - 0.10. \quad . \quad . \quad (50)$$

$$= 1.81 \operatorname{Log}\left(\frac{d^3 \times G \times 342.60 \times (P_1^2 - P_2^2)}{Z^2 \times 10^6 \times T \times L}\right) - 0.10 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (51)$$

$0.10 = 1.81 \operatorname{Log} 1.13566$, hence:

$$\frac{1}{\sqrt{f}} = 1.81 \operatorname{Log} \frac{d^3 \times G \times 301.67 \times (P_1^2 - P_2^2)}{Z^2 \times T \times L \times 10^6} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (52)$$

If $Z = \frac{7}{10^6}$

$$\frac{1}{\sqrt{f}} = 1.81 \operatorname{Log} \frac{6.1565 \times d^3 \times G \times (P_1^2 - P_2^2) \times 10^6}{T \times L} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (53)$$

The Reynolds Number for Gases

The expression for the Reynolds Number is:

$$R = \frac{DUS}{Z} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (54)$$

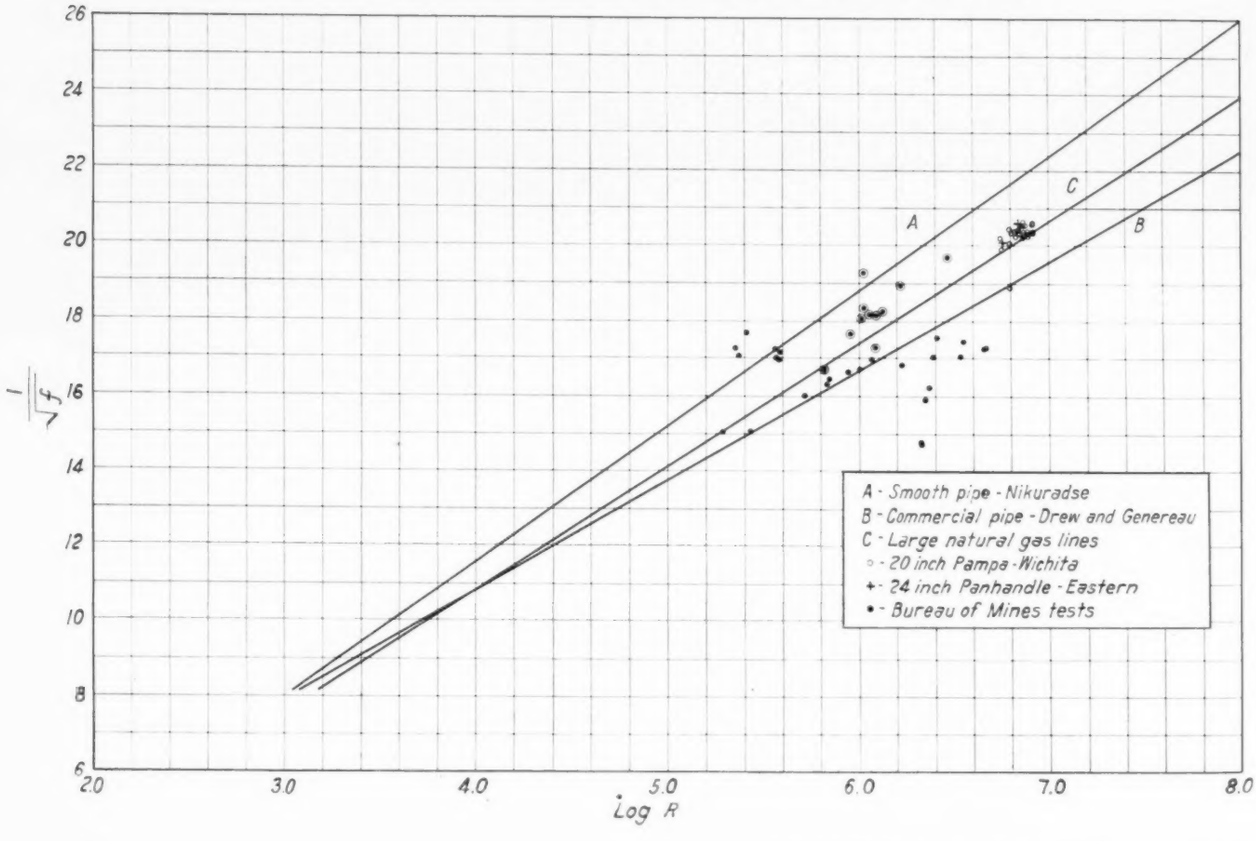
The weight of dry air at 760 mm. of mercury and 32°F. (0°C.) is given by Smithsonian Physical Tables as 0.08071 lb. per cu. ft. At any point in the pipe line where the pressure is P lb. per sq. in. and the temperature is T:

$$S = 0.08071 \times G \times \frac{491.6}{T} \times \frac{P}{760 \times 0.01934} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (55)$$

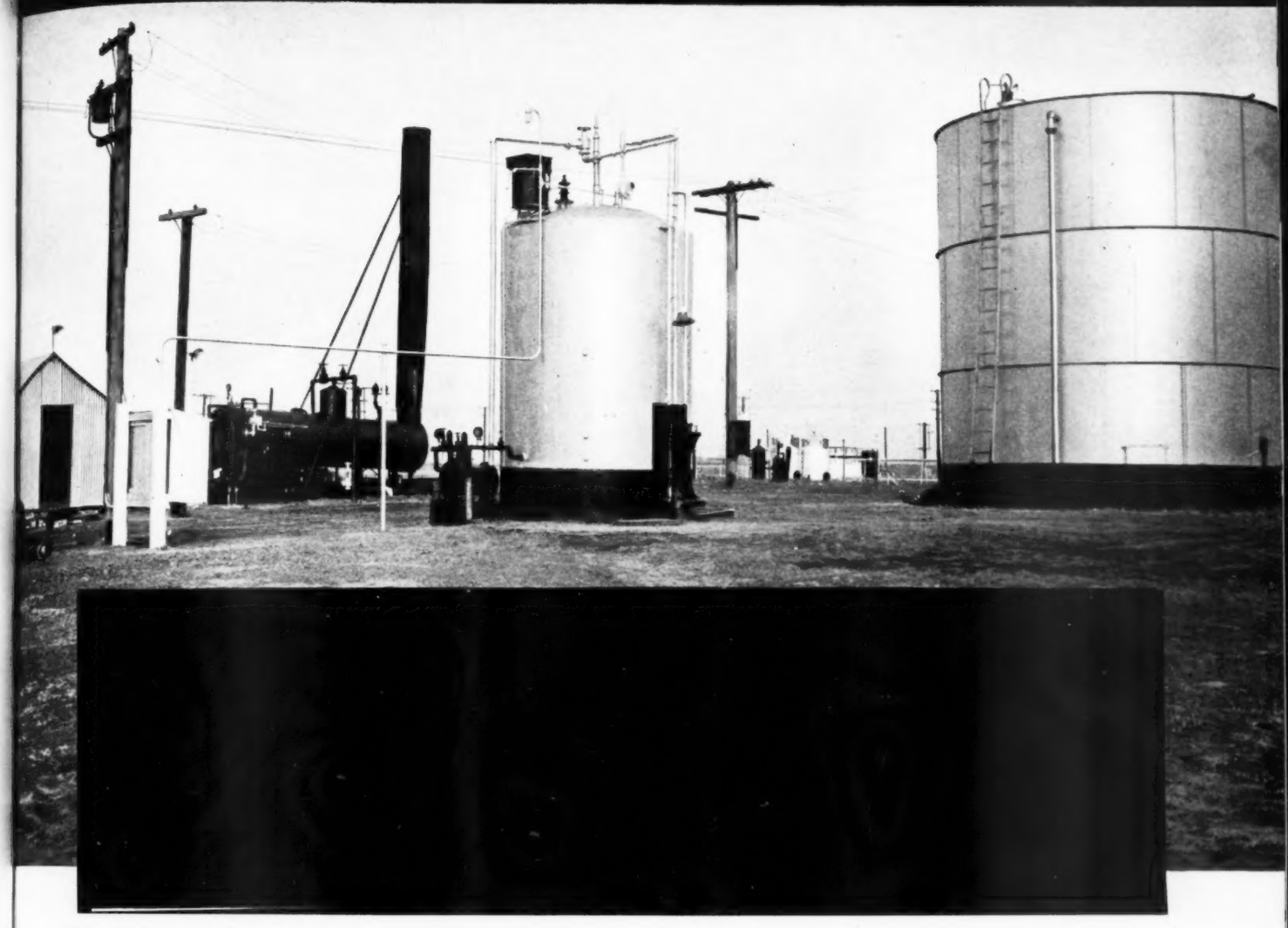
The velocity at the same point is:

$$U = \frac{q}{A} \times \frac{P_0}{P} \times \frac{T}{T_0} = \frac{q \times P_0 \times T \times 144}{d^2 \times P \times T_0 \times 0.7854} = \frac{Q \times P_0 \times T \times 144}{d^2 \times P \times T_0 \times 0.7854 \times 86{,}400} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (56)$$

Fig. 1. Showing the manner in which actual lines conform to various flow formulas



API *Gravity Measured In Dollars*



ON the R. E. Havenstrite, Operator, Larronde Lease at Dominguez, California, the production management noticed that shipping gravities were not consistent. Usually the production was shipped at 30° API . . . and occasionally at 31° API.

To an alert operator, a gain of four cents a barrel in selling price is worth investigating. Petreco engineers assisted in this instance, and recommended a solution of the problem.

With a Petreco Electromatic Dehydrator on the job, every tank has been shipped at 31° API. Cuts on the clean oil are consistently 0.2%, and the operator reports a monthly saving of $750.00.

Production and handling problems vary in every field. Petreco research technicians have made extensive studies of crude oil emulsions from practically every production area, and Petreco engineers are conveniently located in fields everywhere. Why not put your dehydration problems in the hands of oil treating specialists?

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PETRECO

DEHYDRATING DESALTING

Substituting these in equation (54):

$$R = \frac{d}{12 \times Z} \times \frac{Q \times P_0 \times T \times 144}{d^2 \times P \times T_0 \times 0.7854 \times 86{,}400} \times \frac{0.08071 \times G \times 491.6 \times P}{T \times 760 \times 0.01934} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (57)$$

$$R = \frac{Q}{d} \times \frac{P_0}{T_0} \times \frac{G}{Z} \times \frac{477.3597}{10^6} \quad . \quad . \quad (58)$$

$$R = \frac{Q_h}{d} \times \frac{P_0}{T_0} \times \frac{G}{Z} \times \frac{11{,}457}{10^6} \quad . \quad . \quad . \quad (59)$$

If P_0 be 14.735 lb. per sq. in. and T_0 be 519.6

$$R = \frac{Q}{d} \times \frac{G}{Z} \times \frac{13.5371}{10^6} \quad . \quad . \quad . \quad . \quad . \quad (60)$$

$$R = \frac{Q_h}{d} \times \frac{G}{Z} \times \frac{324.89}{10^6} \quad . \quad . \quad . \quad . \quad . \quad . \quad (61)$$

If Z be $\frac{7}{10^6}$, with P_0 and T_0 having values as in (60):

$$R = \frac{Q}{d} \times G \times 1.934 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (62)$$

$$R = \frac{Q_h}{d} \times G \times 46.416 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (63)$$

Note in equations (58) and (59) the line pressure has cancelled out showing that the Reynolds Number is constant throughout the length of the line if there be no input or output of gas. Also the flowing temperature of equation (57) cancels out in equation (58) showing that the Reynolds Number is independent of the temperature of the flowing stream.

EDITOR'S NOTE: *This article will be continued in an early issue of* THE PETROLEUM ENGINEER.

TABLE I

Friction Factor

Comparison of equations and data for plotting

f	$\frac{1}{\sqrt{f}}$	(Log f)+10	Smooth pipe —*(Nikuradse)*		Commercial pipe *(Drew and Genereaux)*		Large natural gas lines *(P. McDonald Biddison)*	
			Log R	R	Log R	R	Log R	R
0.015	8.16497	8.176091	3.053197	1,130	3.088507	1,226	3.194739	1,566
0.010	10.00000	8.000000	3.600000	3,981	3.750000	5,624	3.789620	6,161
0.009	10.54093	7.954243	3.758111	5,729	3.941919	8,748	3.961903	9,160
0.0085	10.84652	7.929419	3.846920	7,030	4.049828	11,220	4.058719	11,448
0.008	11.18034	7.903090	3.943540	8,781	4.167311	14,700	4.164085	14,591
0.0075	11.54701	7.875061	4.049222	11,200	4.295910	19,770	4.279373	19,027
0.007	11.95229	7.845098	4.165524	14,640	4.437542	27,390	4.406293	25,486
0.0065	12.40347	7.812913	4.294411	19,700	4.594627	39,320	4.547001	35,237
0.006	12.90994	7.778151	4.438409	27,440	4.770280	58,920	4.704269	50,614
0.0055	13.48400	7.740363	4.600818	39,890	4.968568	93,010	4.881719	76,159
0.005	14.14214	7.698970	4,786,050	61,100	5.194934	156,700	5.084194	121,400
0.0045	14.90712	7.653213	5.000173	100,040	5.456868	286,300	5.318360	208,140
0.004	15.81139	7.602060	5.251818	178,600	5.765029	582,200	5.593696	392,370
0.0039	16.01282	7.591065	5.307672	200,300	5.833473	681,500	5.654828	451,680
0.0038	16.22214	7.579784	5.365643	232,100	5.904527	802,700	5.718283	522,740
0.0037	16.43990	7.568202	5.425874	266,600	5.978368	951,400	5.784219	608,440
0.0036	16.66667	7.556303	5.488516	309,000	6.055182	1,135,500	5,852802	712,530
0.0035	16.90309	7.544068	5.553739	357,900	6.135182	1,365,000	5.924219	839,880
0.0034	17.14986	7.531479	5.621725	418,600	6.218591	1,654,000	5.998671	996,950
0.0033	17.40777	7.518514	5.692686	492,800	6.305671	2,022,000	6.076389	1,192,300
0.0032	17.67767	7.505150	5.766843	584,600	6.396697	2,493,000	6.157617	1,437,600
0.0031	17.96053	7.491362	5.844452	699,000	6.491985	3,104,000	6.242637	1,748,400
0.0030	18.25742	7.477121	5.925794	842,900	6.591883	3,907,000	6.331758	2,146,600
0.0029	18.56953	7.462398	6.011184	1,026,000	6.696779	4,975,000	6.425325	2,662,700
0.0028	18.89822	7.447158	6.100976	1,262,000	6.807115	6,414,000	6.523729	3,339,900
0.0027	19.24501	7.431364	6.195571	1,569,000	6.923384	8,383,000	6.627410	4,240,400
0.0026	19.61161	7.414973	6.295416	1,974,000	7.046141	11,121,000	6.736860	5,455,800
0.0025	20.00000	7.397940	6.401030	2,518,000	7.176030	14,998,000	6.852650	7,122,800
0.0024	20.41241	7.380211	6.512997	3,258,000	7.313772	20,596,000	6.975422	9,449,800
0.0023	20.85144	7.361728	6.631996	4,285,000	7.460211	28,854,000	7.105924	12,762,000
0.0022	21.32007	7.342423	6.758805	5,739,000	7.616310	41,334,000	7.245011	17,580,000
0.0021	21.82179	7.322219	6.894338	7,840,000	7.783199	60,701,000	7.393688	24,756,000
0.0020	22.36068	7.301030	7.039655	10,956,000	7.962198	91,664,000	7.553125	35,737,000
0.0019	22.94157	7.278754	7.196016	15,704,000	8.154864	142,840,000	7.724705	53,052,000
0.0018	23.57023	7.255273	7.364921	23,170,000	8.363060	230,710,000	7.910081	81,298,000
0.0017	24.25356	7.230449	7.548165	35,332,000	8.589013	388,160,000	8.111228	129,190,000
0.0016	25.00000	7.204120	7.747940	55,968,000	8.835440	684,610,000	8.330560	214,070,000
0.0015	25.81989	7.176091	7.966927	92,668,000	9.105670	1,275,500,000	8.571028	372,410,000

How Chromium Steel Equipment

can lower your refinery costs

REFINERY engineers have found that a marked reduction in the annual maintenance costs can be achieved by taking advantage of the outstanding characteristics of chromium steels for a wide variety of applications. For example, the 4 to 6 per cent chromium steels have excellent resistance to corrosive crudes; the 18-8 chromium-nickel stainless steels have high strength and resistance to corrosion even at elevated temperatures; the 25-12 chromium-nickel steels have maximum resistance to oxidation and scaling, and are used for applications where extremely high temperatures are encountered. The greater service life and lower maintenance costs which these steels impart to oil refinery equipment warrant your investigation.

We do not make steel of any kind, but we have for over 35 years produced "Electromet" ferro-alloys used in making steel. With the knowledge accumulated from this experience, we are in a position to give you, without obligation, impartial assistance in the selection of a chromium steel to suit your particular needs.

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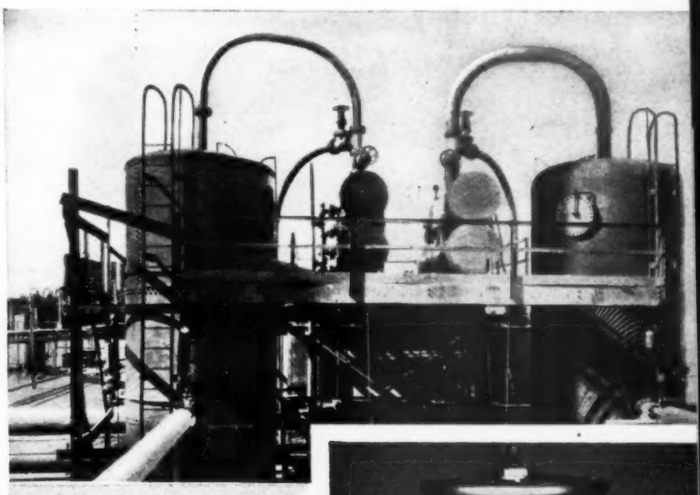


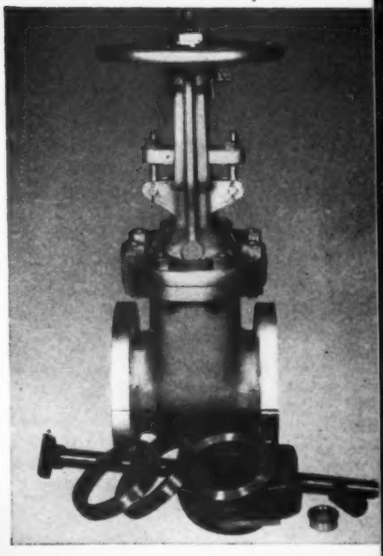
The use of 18-8 chromium-nickel stainless steels permit the use of higher temperatures and pressures in cracking stills.

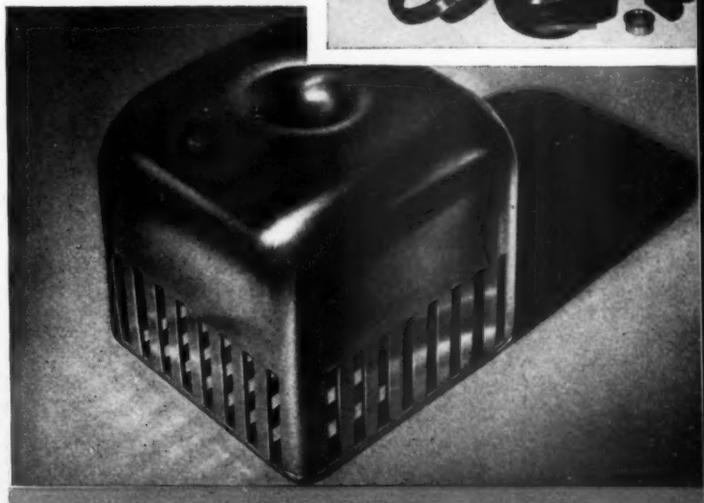
•

Working parts of this 150-lb. gate valve are made of 11.5 to 13 per cent straight chromium iron to resist high-temperatures.

•

Steel containing 17 per cent chromium is used for bubble caps and other fractionating equipment parts to resist the action of corrosive chemicals.





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Pump Bodies
Transfer Lines
Valve Bodies
Fittings
Return Bends
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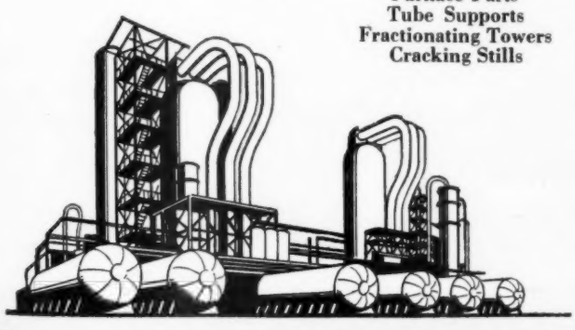
Reaction Chambers
Oil Still Tubes
Distillation Equipment
Valves
Fittings
Header Boxes

Higher-Chromium and Chromium-Nickel Steels

Furnace Parts
Tube Supports
Fractionating Towers
Cracking Stills



SOME USES OF CHROMIUM STEELS IN OIL REFINERIES

Electromet
Trade-Mark
Ferro-Alloys & Metals

P 111.32
P 090.

Development of Seminole Area an Interesting Chapter in Petroleum History

PART 2 (Concluded)

by Floyd L. Swindell, Consulting Engineer

MANY students of the Seminole area have been under the impression that the rapid withdrawal due to the use of gas-lift was responsible for the relatively early migration of water high on many of the structures and account for the uniform water encroachment upon the Bowlegs structure by the fact that gas-lift was not so extensively used. The writer does not have data upon which to base an intelligent discussion on this subject, but is under the impression that the shape of the Bowlegs structure was favorable to an original uniform oil-water contact, that this structure, as it is domal in its characteristics, would not be affected by rapid withdrawal to the extent of some of the others where width of the producing area is considerably less. In regard to the practice of gas-lift as applied to the Seminole area and in view of present knowledge of the subject, it probably is safe to say that it would not be applied under the old practices were similar conditions to be encountered in another area. Here again it should be emphasized that no criticism of the operators is implied or intended. If the practice was wrong as applied and if the practice resulted in needless expenditures, those expenditures probably have been good investments in view of the knowledge gained. Another factor that cannot be overlooked is that a large part of the oil produced by gas-lift reached the market at better than $2.00 a bbl. Had it been held back by the application of slower production methods it would have had to meet the competition of the Oklahoma City and East Texas flush production periods and probably would have been a further disturbing factor in an otherwise demoralized market.

Recovery

Recovery in the Seminole area on a per-acre basis has been exceeded in several other areas, notably in the Oklahoma City and East Texas pools and in some of the pools of the Gulf Coast and Balcones Fault areas. In the pools of the group, production is obtained from Cromwell sand, the Calvin Series, Earlsboro sand, Misener sand, Hunton lime, Simpson lime and dolomite, and the Wilcox sand. From the records available it is not possible, except in a few instances, to make a segregation of the production from each of these horizons. With a few exceptions, however, major production has been obtained from Wilcox sand and it probably is safe to estimate that a total of at least 90 percent and more, probably 95 percent, of the total recovery has been obtained from that horizon. Undoubtedly other pools will be discovered in the area and possibly other horizons will be discovered in the present pools. These will likely be of considerably lesser areal extent and the production obtained will be of comparatively lesser importance.

A photograph and biographical sketch of the writer can be found on page 32 of the August issue of *The Petroleum Engineer* in connection with Part 1 of this article.

As a matter of interest the production as shown by years in Table 3 was plotted on coördinate paper and it was surprising to note that the decline follows very closely a parabola. Some of the interruptions of the line slope can be accounted for by the lessening of production restriction from time to time; others can be explained by the bringing in of new production in upper horizons. The latter condition has been more applicable to the St. Louis pool than to any other pool in the group. The area reached peak production in 1929 and has been continuously prorated from that time until January 1, 1941, when all restrictions were removed in the pools considered herein. It now appears that these restrictive measures over a long period of time have not so affected the pools of the area that their decline departs very far from what formerly was known as a normal decline curve; that the benefits of these restrictive measures have accrued by the smoothing out of a curve that otherwise would have been very erratic, and by the saving of many thousands of dollars in development expense. From this study it appears that a reasonably dependable interpretation of future production might be made through use of a normal decline curve extended into the future by the use of a log-log graph. The dependence to be placed on this interpretation would be based on the fluctuation of the posted price of oil that will control the economic limit.

In Table 4 there is presented pertinent data on all leases where recovery has been 50,000 bbl. or more an acre. The lower limit first was set at 30,000 bbl. an acre but there were so many leases that had exceeded that figure that it appeared impractical to present a table of such great length. As heretofore stated, with the lower limit set at 50,000 bbl. an acre, there were 75

TABLE 3

Year	Total production in bbl. for year	Average weighted posted price, 39°	Indicated gross return from production
1926	12,372,490	$2.39	$ 29,809,251.10
1927	133,655,702	1.46	195,137,324.92
1928	131,255,313	1.43	187,695,097.59
1929	143,401,403	1.48	212,233,076.44
1930	90,459,423	1.23	111,265,090.29
1931	54,420,131	0.54	29,386,870.74
1932	46,554,890	0.93	43,296,047.70
1933	45,024,072	0.71	31,967,091.12
1934	38,199,619	1.06	40,491,596.14
1935	37,694,202	1.06	39,955,854.12
1936	38,131,887	1.16	44,832,988.92
1937	32,966,047	1.28	42,196,540.16
1938	27,236,965	1.08	29,415,922.20
1939	28,230,882	1.08	30,489,352.56
1940	25,548,136	1.08	27,591,986.88
1941 estimated*	11,610,277	1.12	13,003,510.24
	896,951,439		$1,108,767,601.12

*Estimated for the period January 1 to July 16, 1941.

HUNT *All-Steel* SAFETY POP VALVE

Approved by the National Board of Boiler and Pressure Vessels... and by the A. S. M. E.

DESIGNED and manufactured for steam pressures 50 to 500 pounds . . . for air and gas pressures 50 to 3,000 pounds. Nickel steel body; bronze cap, lever and adjustment screws; Cast S-Monel valve and seat; 18-8 stainless steel valve stem; special heat resisting steel spring chrome plated for further resistance to corrosion . . . these fine materials double the life of this valve in contrast to the very short life of conventional pop valves for oil field service. Each valve is individually tested by our own high pressure testing boiler capable of checking pressures to 500 pounds steam . . . a system not available in other plants specializing in oil field work.

Furnished on an economical exchange basis in either flanged or screwed types, 2-inch size, through your local supply store.

This and other Hunt products are fully described and illustrated in the 1941 edition of the Composite Catalog. A reprint of our 20-page section will be sent you immediately, upon request.

HUNT TOOL COMPANY

HOUSTON, TEXAS, U. S. A.

TABLE 4

Operator and lease	Location	No. prod. wells	No. abd. wells	Date first prod.	No. prod. acres	Estimated recovery to 1-1-41, bbl.	Recovery per acre, bbl.
Bowlegs Pool							
Carter, Wise	23–8–6	5	7	4–27	120	6,207,000	51,725
I. T. I. O., Livingston	15–8–6	10	2	11–26	120	6,073,000	50,600
Mid-Continent, Baker	10–8–6	3	0	4–27	30	1,593,000	53,100
Pure, F. H. Reed	14–8–6	14	2	5–27	160	9,548,000	59,675
Sinclair-Prairie, Cumsey	10–8–6	4	0	8–27	40	3,640,000	91,000
Sinclair-Prairie, Harber	10–8–6	8	0	4–27	80	4,147,000	51,838
Sinclair-Prairie, Harjo	14–8–6	3	1	3–27	40	2,000,000	50,000
Sinclair-Prairie, M. Taylor	10–8–6	4	0	5–27	40	2,223,000	55,575
Sinclair-Prairie, Templeton	22–8–6	4	0	7–27	40	3,148,000	78,700
Sinclair-Prairie, Walker	22–8–6	4	0	5–27	40	2,728,000	68,200
Carr City Pool							
Carter, Coker	2–8–5	8	0	4–29	80	4,063,000	50,788
Earlsboro Pool							
Amerada, Anderson	15–9–5	1	3	2–27	40	2,487,000	62,175
Barnsdall, Sango	1–9–5	3	2	3–27	50	3,164,000	63,280
Barnsdall, Saboka	15–9–5	1	0	5–27	10	968,000	96,800
Burke-Greis, Wisner	6–9–6	2	0	8–28	20	1,125,000	56,250
Continental, Spencer	12–9–5	2	2	10–27	40	2,419,000	60,475
Gulf, Bruner	10–9–5	3	1	8–27	40	2,912,000	72,800
Gulf, Noble	12–9–5	1	3	6–27	40	2,707,000	67,675
Magnolia, Gilliam	13–9–5	2	1	12–28	30	1,537,000	51,233
Magnolia, Seay	12–9–5	2	0	4–27	20	1,750,000	87,500
Okm. Mch. & Equip., State	16–9–5	2	2	10–26	40	2,805,000	70,125
Reda Pump, B. W. Hunick	5–9–5	2	0	9–27	20	1,813,000	90,650
Reda Pump, Spencer	12–9–5	1	2	5–27	30	1,945,000	64,833
Sinclair-Prairie, Sango	2–9–5	2	2	10–27	40	3,292,000	82,300
Skelly, Shepard	6–9–6	4	0	9–28	40	3,155,000	78,875
Skelly, Spencer	12–9–5	1	2	7–27	30	1,559,000	51,966
Superior, Ingram	1–9–5	3	0	8–28	30	1,679,000	55,966
Superior, Walker	2–9–5	1	2	4–28	30	2,940,000	98,000
Texas Co., C. Rogers	5–9–5	5	0	6–27	50	3,252,000	65,040
East Earlsboro Pool							
Amerada, Scott	19–9–6	2	0	11–29	20	1,059,000	52,950
Carter, Hopper	19–9–6	4	0	11–29	40	2,136,000	53,400
Magnolia, Anderson "M"	18–9–6	2	2	9–29	40	5,306,000	132,650
South Earlsboro Pool							
Amerada, Edwards	22–9–5	4	0	1–30	40	3,444,000	86,100
Krumme, Anderson	22–9–5	1	0	5–30	10	598,000	59,800
Earlsboro Townsite Pool							
Cities Service, Henry	8–9–5	1	0	6–29	10	783,000	73,800
Little River Pool							
Amerada, Fore	25–8–6	2	0	10–27	20	1,160,000	58,000
Carter, C. Harjo	11–7–6	2	1	8–28	30	4,332,000	144,400
Carter, Jackson	11–7–6	4	0	1–28	40	2,481,000	62,025
Continental, M. Cosar	25–8–6	1	0	7–28	10	553,000	55,300
I. T. I. O., W. E. House "A"	1–7–6	1	0	6–27	10	793,000	79,300
I. T. I. O., Jackson	1–7–6	3	0	9–27	30	1,536,000	51,200
Skelly, Carl	14–7–6	2	0	8–28	20	1,275,000	63,750
Tide Water, House	1–7–6	1	0	11–27	10	937,000	93,700
Mission Pool							
Josaline, Melisse	9–8–6	1	0	11–27	10	888,000	88,800
McMahon, Harjoche	7–8–6	2	0	2–29	20	1,180,000	59,000
Sasakwa Pool							
Sinclair-Prairie, Davis "A"	7–6–8	5	0	3–29	50	2,514,000	50,280
Searight Pool							
Carter, Slick	11–9–6	3	0	5–29	30	1,687,000	56,233
Carter, Strothers	11–9–6	3	0	1–29	30	1,926,000	64,200
Davis, Strothers	3–9–6	2	0	5–27	20	1,040,000	52,000
Sinclair-Prairie, Nevins	5–9–6	1	0	12–29	10	619,000	61,900
Sinclair-Prairie, Polly	3–9–6	4	0	2–27	40	2,399,000	59,975
Seminole Pool							
Burke-Greis, Lulu	7–9–6	1	0	5–30	10	649,000	64,900
Carter, M. Grisso	15–9–6	1	0	8–27	10	567,000	56,700
Carter, M. E. Killingsworth	23–9–6	6	6	12–26	120	11,395,000	94,958
Carter, Strothers	34–9–6	2	2	1–27	40	2,093,000	52,325
Darby, D. Fixico	24–9–6	3	1	2–27	40	3,734,000	93,350
Mid-States, Grisso	36–9–6	1	0	2–27	10	613,000	61,300
Mid-States, Jones	34–9–6	3	1	3–27	40	2,780,000	69,500
Pure, Strothers "A"	26–9–6	15	2	10–26	160	14,660,000	91,625
Sinclair-Prairie, Cudjo "A"	35–9–6	4	2	10–26	60	3,052,000	50,866
Sinclair-Prairie, Cudjo "B"	35–9–6	2	2	10–26	40	2,645,000	66,125
Sinclair-Prairie, R. Cudjo	35–9–6	3	0	3–27	30	2,093,000	69,766
Sinclair-Prairie, Dicey	22–9–6	2	0	5–27	20	1,455,000	72,750
Sinclair-Prairie, Franks	35–9–6	6	2	11–26	80	4,468,000	55,850
Sinclair-Prairie, Giblet	35–9–6	3	1	3–27	40	3,217,000	80,425
West Seminole Pool							
Amerada, Chase	29–9–6	10	0	8–30	100	6,603,000	66,030
Gulf, Pompey	29–9–6	2	0	10–30	20	1,088,000	54,400
Wood, Henry	28–9–6	1	0	4–35	10	601,000	60,100
St. Louis Pool							
Magnolia, G. Fyke "B"	20–7–5	2	0	11–28	20	1,275,000	63,750
Magnolia, Hughbanks	17–7–4	2	0	6–29	20	1,102,000	51,050
Phillips, Youts	19–7–5	3	5	8–28	80	6,930,000	86,625
Pure, Thomas	26–7–4	4	0	11–28	40	4,088,000	102,200
Sinclair-Prairie, Gammon	30–7–5	8	0	8–28	80	5,415,000	67,687
Sinclair-Prairie, Hembree	19–7–5	1	3	6–28	40	5,312,000	132,800

leases to be considered. Throughout this study the practice of allocating 10 acres to each producing well or each abandoned producing well in establishing the recovery per acre was followed. This arbitrary means is open to criticism but in view of conditions the writer knows of no other that would prove more satisfactory. Taking the total saturated thickness as known by the operators, allowing an average pore space of 25 percent and allotting some reservoir space to the large amount of gas that has been produced, it will be readily seen that many of the leases have produced more oil than the reservoir could have held under the known pressure condition. At least one well in the area has yielded in excess of 275,000,000 bbl. and another has exceeded 225,000,000 bbl., both theoretically producing from 10 acres. The larger of these two is thought to be the largest well in the northern Mid-Continent. Among the leases considered in detail Carter Oil Company's C. Harjo with three wells in the Little River pool is the largest with 144,400 bbl. an acre. A summary of these leases, presented at the end of Table 4, shows that Sinclair Prairie Oil Company has recovered the greatest amount of oil with an estimated recovery of 54,367,000 bbl. from a total of 81 wells, 13 of which have been abandoned. This is an average recovery of 67,119 bbl. an acre and 671,198 bbl. per well. The summary also shows that Darby Petroleum Corporation has had the highest recovery per acre with 93,350 bbl. and the highest recovery per well with 933,500 bbl.

Production Control

Oklahoma's first oil and gas conservation law was passed in 1915, primarily to deal with distressed conditions in the Healdton and Cushing pools. When the need for restrictive measures developed in the Seminole area more than ten years later, many of the provisions of that law had not been tested and the powers of the Corporation Commission in this respect were largely unknown. The Seminole City pool was first to reach its peak when on February 22, 1927, it produced 264,500 bbl. from 204 wells. The rapidity with which this field was developed is shown by the fact that its peak production was reached in less than one year from the date of discovery. The Searight pool reached its peak on June 16, 1927, with 41,141 bbl. from 36 wells and less than a month later the Bowlegs pool was at peak production with 194,773 bbl. from 134 wells. With very little decline in the Seminole City, Searight, and Bowlegs pools, and under the influence of the then rapidly growing Earlsboro pool, the district as a whole reached its daily peak production on

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Ring Sticking Problems Solved By this Operator

THIS CASE HISTORY *and the others in this series are typical of the many in our file, supplied by operators of prime movers throughout the country who have found the answer to their ring problems in a change to* COOK'S GRAPHITIC IRON PISTON RINGS,

EQUIPMENT

840 H.P.—2-cycle Diesels

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To stop rings sticking which was making it necessary to pull pistons three to four times a year to release rings.

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Check-up after 3 years' operation (approximately 22,464 hours) with COOK'S Rings showed:—

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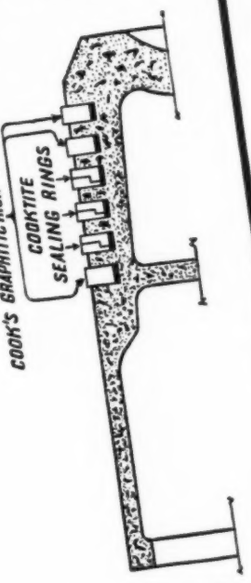
(4) All original COOKTITE Rings still in operation.

SOURCE OF DATA

Chief Engineer of Power Plant.

Case History 40-2-F



This is the COOK'S Rings combination that was used.

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COOK'S GRAPHITIC IRON PISTON RINGS

lower the rate of cylinder wear, increase h.p. output per gallon of fuel and restore new engine power, even after cylinders are badly worn. These results are assured by the combination of (1) COOK'S GRAPHITIC IRON — the highly refined COOK'S Ring material; (2) exclusive designs that positively and permanently seal combustion pressures; (3) pre-conditioned wearing surfaces. You too can reduce your operating and maintenance costs by installing COOK'S Rings next time you make replacements. Ask for informative literature.

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SUMMARY FOR TABLE 4

Operator	No. of leases	No. producing wells	No. abandoned wells	No. producing acres	Estimated recovery to 1-1-41, bbl.	Average recovery per acre, bbl.
Amerada	5	19	4	230	14,753,000	64,143
Barnsdall	2	4	2	60	4,132,000	68,866
Burke-Greis	2	3	0	30	1,774,000	59,133
Carter	9	38	16	540	36,887,000	68,309
Cities Service	1	1	0	10	783,000	78,300
Continental	2	3	2	50	2,972,000	59,440
Darby	1	3	1	40	3,734,000	93,350
Davis	1	2	0	20	1,040,000	52,000
Gulf	3	6	4	100	6,707,000	67,070
I. T. I. O.	3	14	2	160	8,402,000	52,512
Josaline	1	1	0	10	888,000	88,800
Krumme	1	1	0	10	598,000	59,800
Magnolia	5	10	3	130	10,889,000	83,761
McMahon	1	2	0	20	1,180,000	59,000
Mid-Continent	1	3	0	30	1,593,000	53,100
Mid-States	2	4	1	50	3,393,000	67,860
Okm. Mch	2	2	2	40	2,805,000	70,125
Phillips	1	3	5	80	6,930,000	86,625
Pure	4	33	4	360	28,296,000	78,600
Reda Pump	2	3	2	50	3,758,000	75,160
Sinclair-Prairie	18	68	13	810	54,367,000	67,119
Skelly	3	7	2	90	5,989,000	66,544
Superior	2	4	2	60	4,619,000	76,983
Texas	1	5	0	50	3,252,000	65,040
Tide Water	1	1	0	10	937,000	93,700
Wood	1	1	0	10	601,000	60,100
	75	241	65	3,050	211,279,000	69,271

July 30, 1927, when 666 wells produced 529,596 bbl. Eleven days later the Earlsboro pool produced at its peak rate of 209,874 bbl. from 108 wells.

On May 15, 1926, the purchasing companies had posted a price of $2.53 a bbl. for 39 to 39.9-gravity oil. With pipe lines taxed beyond their capacity and oil going into storage the need for restrictive measures became imperative if physical and economic waste were to be avoided. This condition had been anticipated by the operators and in the Fall of 1926 a meeting had been held in Tulsa at which time an organization was perfected and plans were made for a more orderly development. The committee included four representatives from the larger companies and three representatives from companies not having affiliations with pipe lines or refineries. A committee of five attorneys was also appointed and Ray M. Collins, veteran Oklahoma oil man, was selected as umpire. On November 6, 1926, an agreement was entered into by the owners of production and undeveloped acreage under the directions of the committees and the umpire. This agreement was to have been for 30 days and provided for proration of pipe line runs, restricted the drilling of Wilcox sand wells, and restricted the widely developing practice of heavily shooting the producing horizons. No wildcat well brought into production during the period of the agreement was allowed to produce in excess of 100 bbl., many were restricted to 50 bbl. a day and some were shut in for long periods of time. By this time no leases were available over a wide area and everyone owning property in the highly prospective localities desired to drill immediately and obtain the cream of the large production. This will give some idea of the problem with which the advisory committee and umpire were faced. Before the activities of this voluntary restrictive movement could be made felt the posted price was reduced to $2.04 a bbl. on November 17, 1926. Three months and five days later the price was further reduced to $1.79 a bbl. and on March 5, 1927, it was reduced to $1.56 a bbl. Seven days later a cut to $1.34 was posted and this was the last reduction until early in the following year. Although these reductions came rather rapidly and within less than five months the price had been reduced almost 50 percent, the work of the committee and umpire cannot be discounted and these gentlemen should be given credit for laying the foundation of the present efficient and smooth-working proration procedure.

Economics

It was estimated by engineers of the U. S. Bureau of Mines that the average cost for drilling and equiping a flowing well was approximately $67,000; for a gas-lift well, $97,000, and for a dry hole, $56,000. Figures are not available for a careful analysis of the economics of production in the area but some are known and it is the purpose here to arrive at a rough approximation of the probable net income from this great area. Many of the wells were placed on gas-lift and remained on this method of production from a few days to more than two years but almost all ultimately were placed on the pump. Taking an average condition it is believed that an estimate of $80,000 for drilling and equipping the average well is conservative. On this basis the approximately 4000 producing wells drilled to the lower horizons during the original campaign cost $320,000,000. No figures are available on the cost of drilling subsequent wells to the shallower horizons and for the drilling of dry holes during the original campaign, but it is believed that the estimate of $50,000,000 is conservative. To this should be added an estimate of $5,000,000 for leaseholds, rentals, and miscellaneous pre-development costs. Pumping conditions vary widely over the area and it is known that a considerable amount of sucker rod and other pumping difficulties were encountered in the Earlsboro and St. Louis pools. For this reason, in estimating lifting costs 25 cents a bbl. has been used for the average and 35 cents for Earlsboro and St. Louis. On this basis total lifting costs would be $260,000,000. It is estimated that royalty owners, exclusive of original bonuses and lease rentals, have received a total of $140,000,000. Assuming further a bill of $225,000,000 state and federal taxes, damage claims, etc., the total expenditure amounts to the following:

Drilling and equipping 4000 wells	$320,000,000
Dry holes and shallower wells	50,000,000
Leaseholds, rentals, etc.	5,000,000
Lift costs	260,000,000
Royalties	140,000,000
State and federal taxes, damage claims, etc.	225,000,000
TOTAL	$1,000,000,000

Upon the basis of recovery estimates the gross income to July 16, 1941, was estimated at $1,108,767,601.12 as shown in Table 3. This would indicate a net return of $108,676,601.12, exclusive of income from natural gas, natural gasoline, and from salvaged equipment.

Aid of Inventors Sought

American oil companies conducting research operations and laboratory work have been requested by the National Inventors Council to review each industrial development from the standpoint of application to military or naval needs and to report discoveries that might be helpful in developing the national defense program.

Military, naval, and other defense establishments now have such extended ramifications, it was explained, that almost any new industrial idea may be of interest, especially with work requiring the utmost in precision and modern methods being undertaken at navy yards and arsenals.

Directors of research and development operations have been requested to make their reports to the Council at Room 7424, Commerce Building, Washington, D. C. Dr. C. F. Kettering, of General Motors Corporation, is chairman of the Council, and Dr. Thomas Midgley, Jr., of Ethyl Gasoline Corporation, is vice-chairman.

open letter

to the Brass Hats

of 2700 Oil Companies

There's an old saying that it's sometimes possible to get so close to the forest you can't see the trees. This is true of operations even in a small company like ours, and possibly also applies to larger corporations in the oil business. The purchase of heavy oil field equipment, involving initial expenditure running into many thousand dollars, receives the attention and consideration of key men in the company. On the other hand, the purchase of smaller items, such as a plunger pump or a string of sucker rods, doesn't always receive the consideration or attention which we believe this purchase merits.

If every oil company takes its total yearly bill for deep well plunger pumps and sucker rods and adds to it the amount of extra production that is obtained by quality pumping equipment it will appreciate that here is an expense item of no mean proportions. We know of one oil company which during 1941 plans to spend approximately $140,000 for deep well plunger pumps and sucker rods. Purchases that reach a figure such as this rightfully deserve consideration of top executives.

It is at this point that Axelson Pumps and Sucker Rods enter the picture. If you want to pump the greatest quantity of oil at the lowest cost per barrel you will install Axelson Pumps and Sucker Rods. They are not always the cheapest, if you consider initial cost, but they are the most economical day in and day out, under favorable and unfavorable conditions, both from the standpoint of lowest long run cost and increased production. Check up today on what your pump and rod bill was during 1940. Then you'll appreciate why we say this is a purchase which justifies the consideration of top men in every oil company.

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Progress of Intermittent Flow Devices For Producing Oil

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☆ Early development is traced—Data on present-day intermitting installations are given

PART 1

by S. F. Shaw, Consulting Engineer

INTERMITTENT flowing of oil wells is not a new method of lifting oil. Apparatus for intermittent, or pulsating, flow was patented by F. S. Pease (47034) on March 28, 1865. On January 29, 1867, Henry Searle was granted a patent (61571) for intermitting wells by a method whereby one well would be flowed until the liquid was lifted that had accumulated in a chamber at the bottom of the well, after which the compressed air or steam would be turned into another well for a similar purpose, the action being conducted continuously in this manner throughout the day. Another patent (371006) was granted to John William Waits on October 4, 1887, for the purpose of intermittently flowing a well. On June 20, 1916, E. A. Watts and I. L. Dunn were granted a patent (1187579) for a displacement pump, and on October 31, 1916, Elmer A. Watts was granted a patent (12029-32) for an ingenious pump of intermittent type that was automatic in action, this action being controlled by a float operated by the rise and fall of the fluid in a chamber suspended in the well. Horace M. Staggs was granted a patent (1683930) on September 11, 1928, covering a bottom-hole valve that would permit compressed air or gas to enter a chamber, displace the accumulated oil, and lift it to the surface. On September 5, 1939, patent (2171812) was granted to J. D. Nixon for a method of intermittently causing the fluid in the tubing of a well to be discharged, employing a wire-line arrangement to effect the operation of the valves in the tubing string.

One of the first papers giving definite examples of results accomplished by intermittent flow and analyzing this type of flow, was that of Morgan Walker[1], which described work that had been done by the Amerada Petroleum Corporation in the Seminole field a short time previous to the date of the paper.

S. F. SHAW

received a degree in mining engineering from Columbia University in 1903—From that time until 1926 he was with various mining organizations in Mexico and Costa Rica—While with the American Smelting and Refining Company in Mexico a part of his work involved dewatering of mines by the application of air-lift—This experience and knowledge he later applied to the lifting of oil by air-gas lift methods—Since 1926, during which time he has been connected with various oil companies and has operated as a consulting engineer, he has constantly studied and applied air-gas lift principles to oil production and is considered an authority on the subject—His home is in San Antonio, Texas.

Another paper that was of value in promoting discussion of the method of intermittent flow was written by R. Van A. Mills[2] in 1928, which described the automatic method of intermitting by means of a chamber that was in use in some shallow fields of northeastern Oklahoma. This paper had been preceded by other articles describing some installations of this type, and the analysis by Mills aroused much interest in the subject. After investigating the method of intermittent flow, the Carter Oil Company in 1929-31 made several installations at Cromwell, Burbank, and in various of the pools in the Seminole area, and obtained considerable data on the operation of the method as developed to that time. A description of intermitting operations of the Carter Oil Company in the Seminole field was given by K. C. Sclater in 1930[3].

Progress in the development of this method, as shown by actual operations in various fields, is indicated by noting the periods when various types of intermittent flow were being carried on.

The use of manually-operated admission valves is the simplest form of handling intermittent flow. This method is said to have been used in and around Oil City, Pennsylvania, 40 or 50 years ago, and in one instance in this area, wells were "blown" every few days by a compressor installed in a neighboring blacksmith shop. The method was used in Corsicana, Texas, by M. T. Chapman in 1899 for periodically blowing-out oil from shallow wells[4]. Manually-operated valves were employed to some extent at Seminole in wells that were not provided with chambers, and this method is being employed in the Oklahoma City field at the present time.

In 1926, a system of automatic, intermittent flow, controlled from the surface was installed by the Loomis Oil Well Company and engineers of the E. J. Miley Company on six wells of the Miley company in the Torrance field, California[5], with resultant reduction in the quantity of input gas required.

In 1927, the K & G system[6] was installed on three wells in the Athens-Rosecrans field, California, using magnetically controlled valves.

[1] "Intermittent Injection of Gas in Gas-Lift Installations," by Morgan Walker, A.I.M.E. *Petroleum Development and Technology*. Vol. 82 (1928-29), p. 151.

[2] "Automatic Flowing of Small Wells," by R. Van A. Mills. *Oil and Gas Journal*, November 8, 1928, p. 36.

[3] "Wells Produced by Intermittent Gas-Lift Yield Encouraging Results," by K. C. Sclater. *The Petroleum Engineer*, September, 1930, p. 50.

[4] *The Gas-Air Lift Pocket Book*, by Robert Stirling (1929), p. 2. Published by Spon and Chamberlain, New York.

[5] "Gas-Lift Reduces Mechanical Equipment and Attendant Depreciation," by George Reid. *Oil Weekly*, October 8, 1926, p. 29.

[6] "Intermittent Gas-Lift Pumping of Several Wells With One Compressor," by Robt. E. Robinson. *Oil Field Engineering*, October, 1927, p. 71.

Fig. 1. One type of control for intermitting

Records at hand do not indicate just when the method of using gas pressure to operate an admission valve was first employed. The Smallamatic valve, operating on this principle, was in use in 1928 on wells of the Tidal Oil Company in the Chelsea district, Oklahoma[7]. In this method, a chamber was employed in the bottom of the well. This method was superseded by the Max-i-flo valve, which was used in shallow wells in northeastern Oklahoma and southeastern Kansas. It has also been employed in Argentina and Trinidad. The valve mechanism is controlled through a pilot tubing run into the well beside the producing string, the action of the valve being dependent on the rise of the liquid level in the well. The method was also employed in conjunction with a pressure tank on the surface, in which the valve mechanism operated to admit gas into the well when the pressure in the tank built up to a predetermined point by the admission of a continuous but very small stream of gas into the tank.

In 1929, the Jat system, using magnetically-controlled valves, was employed in the Brea Canyon field, California[8], by means of which production was increased over the use of straight gas-lift, and input-gas requirements per barrel were reduced. The Jat system was introduced into the Seminole field in 1929[9], and spread to various other places in the United States, to Roumania[10], Trinidad[11], and Venezuela.

Time-cycle systems of operating the valve mechanism have consisted of the tipping cylinder in which a stream of water or kerosine flowed first into a compartment at one end of the cylinder, then into the compartment at the other end. A simpler method has since been employed in which the operation is controlled by a clock movement. The Jat gastributer is a form of time-cycle mechanism in which a small electric motor revolving a disk, moves a mercury contact tube, thereby operating a magnetic valve. Time-cycle controlled mechanism operated by clockwork made considerable headway in the Oklahoma City field in 1934-1936, and is represented by the Fisher, Hanlon and Waters, Oklahoma Brass and Iron Company, and Shipman intermitters. (Fig. 1.)

Various adaptations of the intermittent method have been developed since the early types. The plunger-lift has made successful headway in various states and countries.[12, 13] The Clark bottom-hole intermitter was exten-

[7] "Automatic Flow Device Cuts Lifting Cost on Old Lease," by Wallace Davis. *Oil Weekly*, October 19, 1928, p. 319.

[8] "Advanced Methods Reduce Lifting Cost at Brea Canyon," by Art White and Brad Mills. *Oil Weekly*, November 29, 1929, p. 35.

[9] "Intermittent Induced System for Gas-Lift is Successful," by L. G. E. Bignell. *Oil and Gas Journal*, December 26, 1929, p. 24.

[10] "Production After Gas-Lift," by L. W. Rogers. *Journal Institution of Petroleum Technologists*, Vol. 18 (1932), p. 787.

[11] "Displacement Pumping as Applied to Oil Wells," by Albert Millar. *Journal Institution of Petroleum Technologists* (London), Vol. 19 (1932), p. 445.

[12] "Plunger-Lift Makes Flowing Wells Out of Pumpers," by H. W. Fletcher. *Oil Weekly*, January 29, 1932, p. 78.

[13] "Plunger-Lift for Pumping Deep Wells," by H. W. Fletcher. *Trans. Society of Mechanical Engineers* (1936), p. 361.

(Continued on Page 86)

TABLE 2

Type 2. Data on intermittent flow with valve in tubing. No chamber or packer

Well	Place	Casing diameter, in.	Tubing diameter, in.	Total depth, ft.	Operating depth, ft.	Bbl. of fluid per 24 hr.	Cu. ft. gas per bbl. of fluid	Cycles per day	Operating pressures, lb. per sq. in.
A	Texas.....	7	2½	4800	1200	826	104	144	450
B	East Texas.	5½	2	3695	1532	40	40	72	375

Fig. 2. Automatic intermitting flow valve actuated by differential pressure

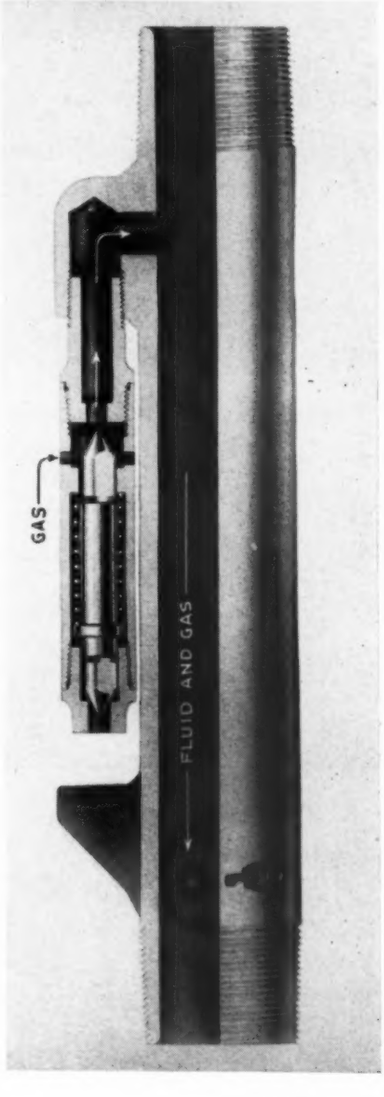


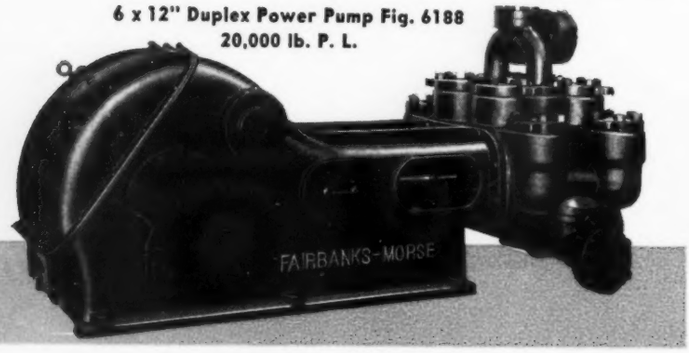
TABLE 1

Data on intermittent flow, Type 1. No chamber, valve or packer

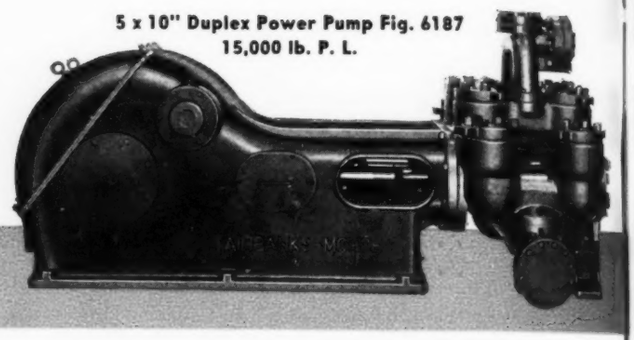
Well	Depth, ft.	Field	Casing diameter, in.	Tubing diameter, in.	Bbl. per day	Cu. ft. gas per bbl.	Pressures, lb. per sq. in.	Cycles per day
A	4158	Seminole.....	7	2½	70	9000	230	120
B	4164	Seminole.....	7	2½	104	6000	175	96
C	4125	Seminole.....	7	2½	183	5380	240	80
D	4349	Seminole.....	7	2½	260	950	200	60
E	4208	Seminole.....	7	2½	350	685	250	80
F*	....	Seminole.....	....	....	1124	950	245	....
G*	....	Seminole.....	....	....	900	850	245	....
H*	....	Seminole.....	....	....	508	1840	173	....
I*	....	Seminole.....	....	....	279	2080	180	....
J	6408	Oklahoma City....	9⅝	3	110	10393	400	24
K	6408	Oklahoma City....	9⅝	3	128	8903	400	24
L	6369	Oklahoma City....	8⅝	3	492	5259	400	24
M	6369	Oklahoma City....	8⅝	3	519	5322	400	24

*See reference 1, p. 158.

6 x 12" Duplex Power Pump Fig. 6188
20,000 lb. P. L.

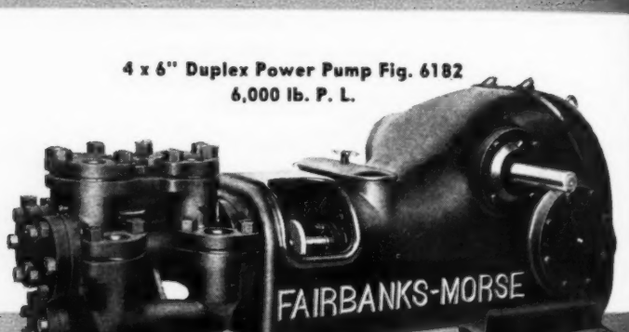


5 x 10" Duplex Power Pump Fig. 6187
15,000 lb. P. L.

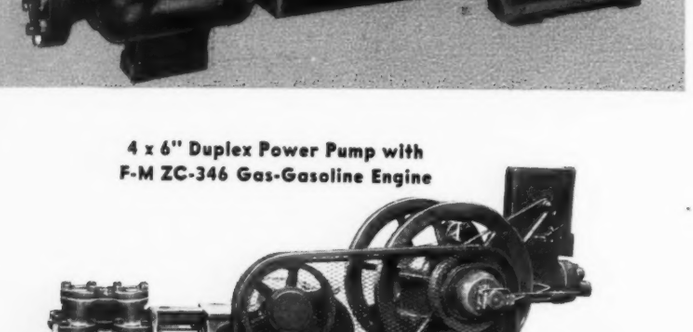


5 x 8" Duplex Power Pump Fig. 6183
8,000 lb. P. L.

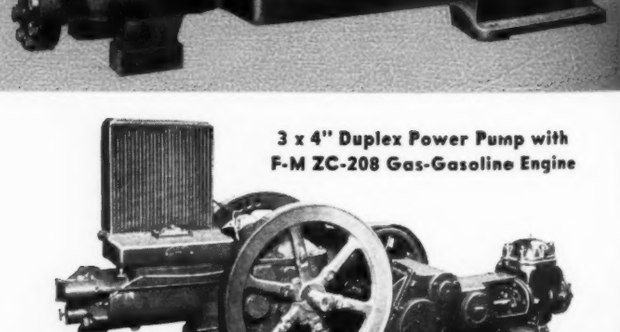
4 x 6" Duplex Power Pump Fig. 6182
6,000 lb. P. L.



4 x 6" Duplex Power Pump with
F-M ZC-346 Gas-Gasoline Engine



3 x 4" Duplex Power Pump with
F-M ZC-208 Gas-Gasoline Engine



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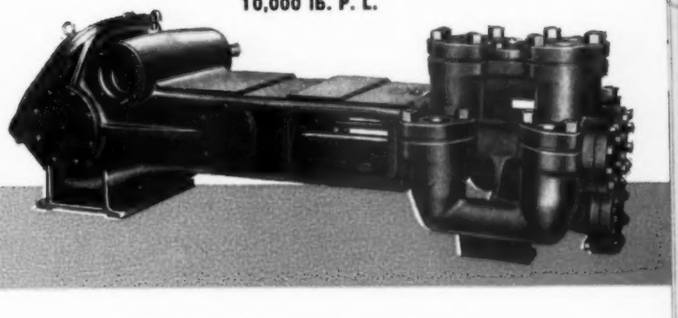
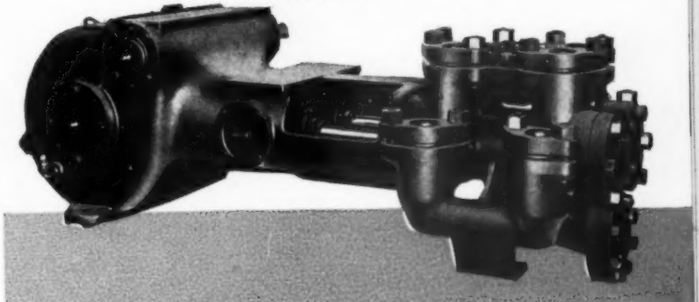
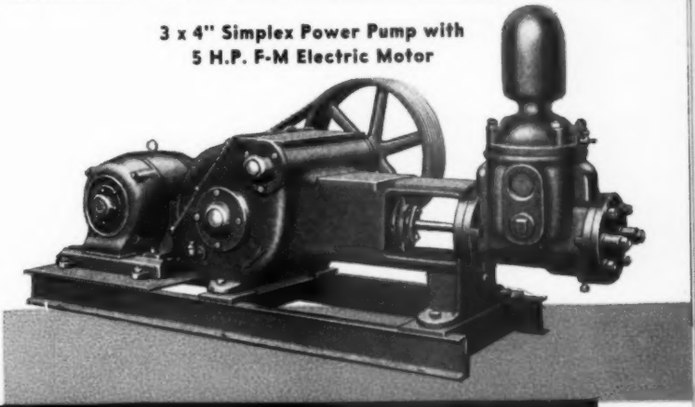


4 x 6" Duplex Power Pump Fig. 6181
3,800 lb. P. L.



3 x 4" Simplex Power Pump with
5 H.P. F-M Electric Motor



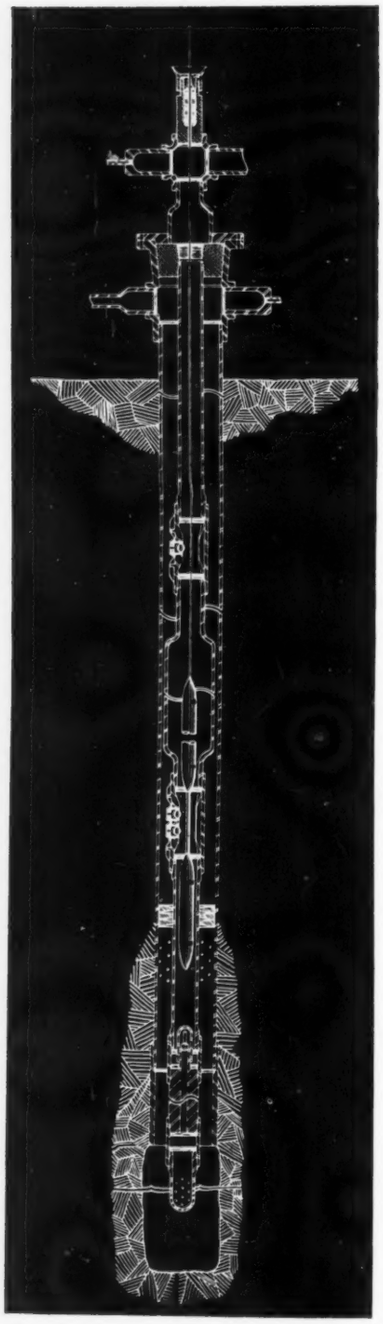


Fig. 3. Surface-controlled wire-line intermitter installation

(Continued from Page 83)

sively used in the Oklahoma City field in 1934-36. The wire-line intermitter was invented in 1927, but did not come into commercial use until about 1938, when it found successful application in Gulf Coast fields, and has spread to various other fields since that time[14].

The evolution of intermittent flow has been so rapid and varied that a classification of the various types made during one year is out of date the next year. At the present time, the methods might be classified as follows:

1. No chamber, packer or valve in the wall.
   Gas admitted to casing or tubing, and flow is through the tubing or casing.
   Gas admission valve usually at the surface operated by:
   (a) manually
   (b) tipping cylinder
   (c) clock intermitter
   (d) electric motor.
2. Valve in tubing; no chamber or packer (open type).
   Gas admitted through the casing and into the tubing through a valve operated by:
   (a) differential pressure
   (b) wire line
   (c) lifting or rotating the tubing.
3. Two tubing strings with chamber and standing valve; no packer in casing.
   (A) Gas admitted to annular space by:
   (a) surface intermitter.
   (B) Gas admitted to the tubing and flowed through the annulus by:
   (a) manual operation
   (b) tipping cylinder
   (c) time-cycle intermitter, operated by clock movement
   (d) electric motor and magnetic valve
   (e) differential gas pressure
   (f) lifting or rotating the tubing
   (g) liquid-operated valve, controlled by gas pressure.
4. Packer and valve; no chamber. (closed type).
   Gas admitted through the casing and then through ports into the tubing through valve operated by:
   (a) differential pressure
   (b) wire-line intermitter
   (c) lifting or rotating the tubing.
5. Packer, chamber, and valve.
   (A) Gas is admitted through the tubing and flowed through casing by surface intermitter.
   (B) Gas admitted through casing, entering chamber through valve operated by:
   (a) differential pressure
   (b) wire-line intermitter
   (c) lifting or rotating the tubing.
   (d) surface intermitter.
6. Plunger-lift.

TABLE 3
Performance data on intermittent Type 3, with chamber and valve. No packer

Place	Well	Total depth, ft.	Tubing diameter, in.		Bbl. per day	Cu. ft. input gas		Pressure, lb.	Cycles per day
			Outer	Inner		Per day	Per bbl.		
Burbank	A	2808	2	¾	8	32,000	4000	.....	..
Burbank	B	2820	2	1	14.1	46,530	3300	.....	..
Burbank	C	2870	2	1	6.3	28,300	4500	.....	..
Burbank	D	2870	2	1	20.5	67,650	3300	.....	..
Cromwell	E	3390	2	1	22	92,400	4200	270	53
Cromwell	F	3439	2	1	22.5	94,500	4200	270	80
Seminole	G	4352	3	1½	45	135,000	3000	225	48
Seminole	H	4245	3	1½	80	228,000	2850	370	80
Seminole	I	4213	4	2	83	290,500	3500	250	80
Seminole	J	4240	3	1½	100	250,000	2500	325	80
Seminole	K	4158	3	1½	135	337,500	2500	325	96
Seminole	L	4205	3	1½	160	320,000	2000	400	96
Seminole	M	4214	3½	2	185	462,500	2500	350	96

Type 1. No chamber, packer or valve.

The simplest form of intermittent flow consists of blowing-out from time to time the oil that has accumulated at the bottom of the well. A tubing is run into the well, and the gas is injected through either the tubing or the casing, depending upon the diameter of the tubing and upon the condition in the well. No chamber or valve is used in the well. This method serves the purpose fairly well when there is a high reservoir pressure and when the sand is tight, under which conditions the oil slowly oozes through the sand into the well and in the course of time rises to a high fluid level. The injection of gas will not drive the oil out of the well through the tight sand back into the reservoir in the short time that the gas is being injected, and a quick injection of a sufficient supply of gas will clean out the accumulation of oil fairly completely.

Probably a more complete clean-out of the well is obtained if the gas is injected through the casing and the oil flowed through the tubing, but if the fluid level is high at the time the gas is injected, a very high gas pressure may be required to begin the flow in this manner, especially if the casing diameter is large and the tubing diameter is small.

The admission of gas may be handled manually with this method, and if the intervals are far apart, this is the manner in which the operation is often handled. Admission of gas also may be handled by any of the forms of surface intermitters. This method has been used in Pennsylvania oil

[14] "Gas-Lift Production," by W. J. Sutton. *International Oil*, July, 1940, p. 87.

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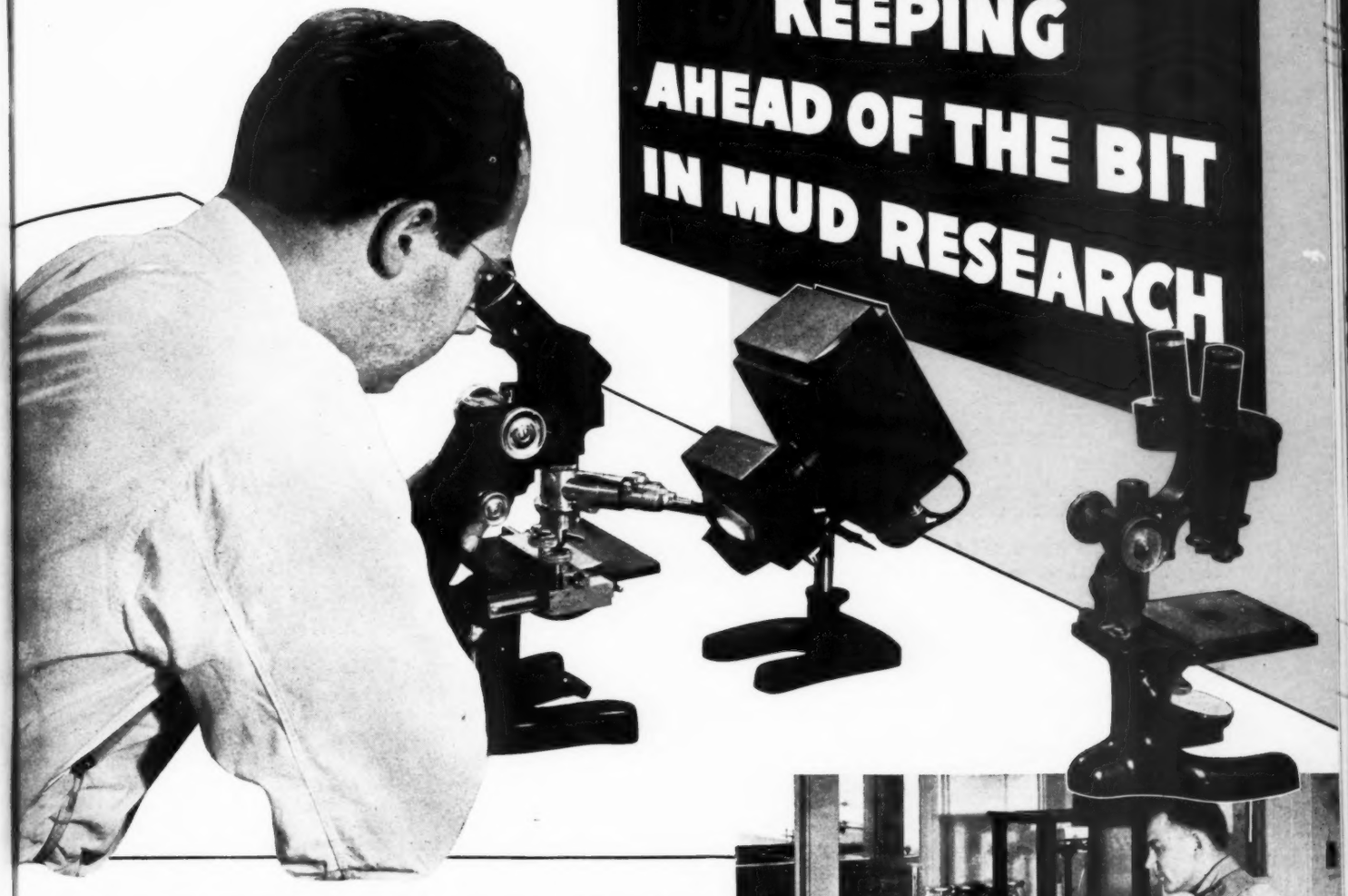

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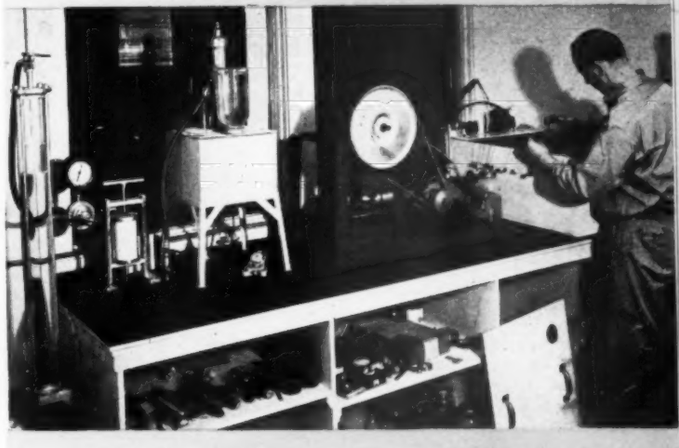

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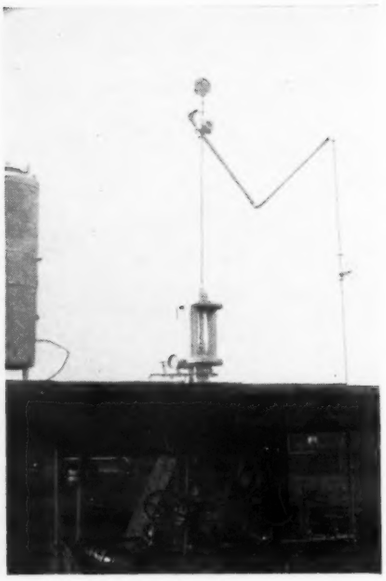


Fig. 4. Valves in tubing are actuated by raising and lowering the tubing

wells in which some of these wells are not flowed for several days, and then a charge of compressed air is admitted to the well to blow out the accumulation of oil. In 1928, Haskell[15] stated that "these wells average 2000 ft. deep and are flowed two or three times per week by turning air under pressures of from 175 to 225 lb. per sq. in. into the annular space between the casing and tubing. This air pressure acts on the top of the oil in the well and forces it up the tubing to the surface. To reduce the air pressure required to lift the oil, a number of ⅛-in. holes are placed at different levels in the tubing so that the air may come in contact with the rising oil and aërate it, thus making it lighter to lift. In the very hilly country in which these wells are located a pumper can flow about 15 wells per day. These wells average about 2.4 bbl. of oil and little or no water per flowing well and require about 1500 cu. ft. of air per bbl. of oil lifted. Where much water is to be handled by this means of pumping great care has to be taken to prevent cutting. The great saving in lifting cost effected by this method of lifting oil is the absence of pulling troubles."

Data on intermittent flow of Type 1, are given in Table 1.

Type 2. Valve in tubing. No chamber or packer (open type).

In this type of intermittent flow, a single string of tubing is run into the well, with one or more valves inserted in couplings of the tubing string, at suitable distances apart. The valves can be operated as follows:

(a) Valves are inserted in the tubing couplings and maintained in open position by a spring, either flat or coiled, and closed by differential pressure after the flow has subsided. The action of the "kick-off" valve, or "flow" valve can be controlled more accurately when a surface intermitter is employed. (See Fig. 2.)

(b) A weight-bar on a wire line which is suspended from the surface, is pulled into the valve assembly, thus forcing the valves from their seats, where they are held in place by the pressure of the gas in the casing when the weight-bar is not in the assembly. The flow takes place through the tubing. (See Fig. 3.)

(c) The tubing is lifted from its seat, which is held in place by an anchor or slips, thereby allowing gas to pass from the casing into the tubing, or from the tubing into the casing. This is represented by the Chenault design. The Acme valve could also be employed in this manner but so far as known has not been so applied. (See Fig. 4.)

Intermittent flow of Type 2 is employed in wells that will not flow naturally, but where there is a high fluid level, and where the daily production is sufficiently small so that the flow of the slug of oil does not result in the gas in the casing (or tubing) displacing the oil down to the bottom of the tubing thus permitting the gas to pass around the bottom of the tubing. Likewise in the type in which the differential valves are used, if several valves are inserted in the tubing string, the flow during each cycle should not be of such volume and under such pressure as to cause the gas to displace the fluid down to the next lower valve.

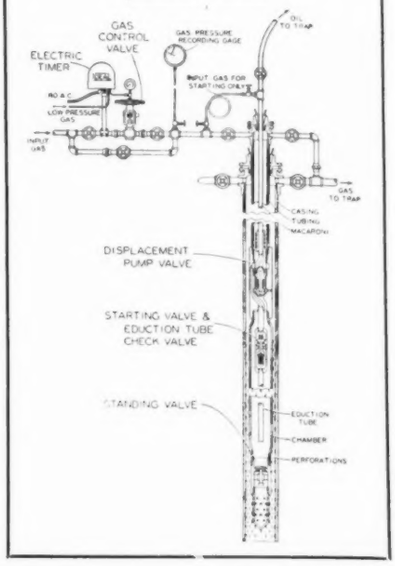
Examples are given in Table 2[14].

Type 3. Two tubing strings with chamber. No packer.

In this type, a chamber provided with a standing valve is run on the end of an outer tubing string. A smaller tubing is run inside the outer tubing and suspended with its lower end near the standing valve. In another arrangement, a seat is set in the chamber and a standing valve assembly is run on the end of the smaller tubing string, and the valve is lowered into the seat in the chamber. In the second method, perforations are made in the inner tubing above the standing valve to permit the gas to pass from the chamber into the inner tubing.

The inner tubing may be sealed-off from the outer tubing and a differential pressure valve inserted so that the gas supply from the annulus will

Fig. 5. This arrangement employs tubing strings and a chamber. No packer is used



be closed off when the pressure declines to a given point. By this means, a large portion of the residual gas left after each flow is trapped in the annulus and, therefore, the energy is not wasted. (See Fig. 5.)

In operation with Type 3, the oil accumulates in the chamber until a predetermined level is reached, which point is ascertained by test. At that time gas is admitted to the annular space, displacing the oil from the chamber into the inner tubing, and lifting the oil to the surface. The gas is shut off at a point determined by test to be the proper point. As a beginning point for testing operations, the gas is often closed off when the top of the slug reaches the surface. The injection of gas to the annular space is controlled by one of the surface intermitters listed in the classification.

When the gas admission in this type is controlled solely from the surface, after each flow there is a considerable quantity of gas remaining in the annular space and in the pipe line from the well back to the intermitter valve. The energy in this residual gas is lost, and often amounts to as much as twice that required for the actual lifting operation. The loss of energy is considerably reduced when a differential valve is inserted close to the chamber, which is partly controlled by the surface intermitter. Data on the operation of Type 3 are given in Table 3[16].

Maximum efficiency in utilization of the energy in the gas is obtained when wire-line intermitters operate the admission valve situated in the tubing,

[15] "600 Eastern Wells Repressured for Less Than $100 per Acre," by R. M. Haskell. *Oil Field Engineering*, July 1, 1928, p. 32.

[16] *Gas Lift Principles and Practices* (1929), by S. F. Shaw, p. 131. Published by Gulf Publishing Company, Houston.

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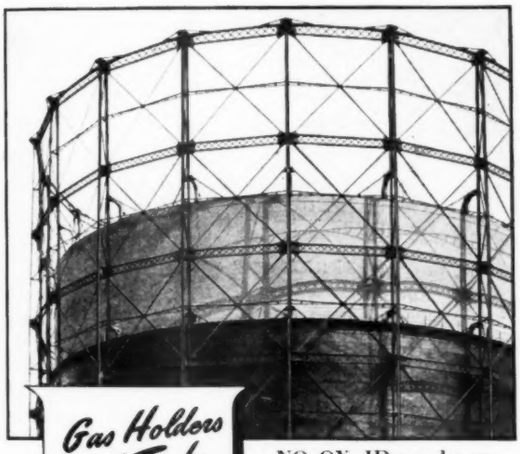

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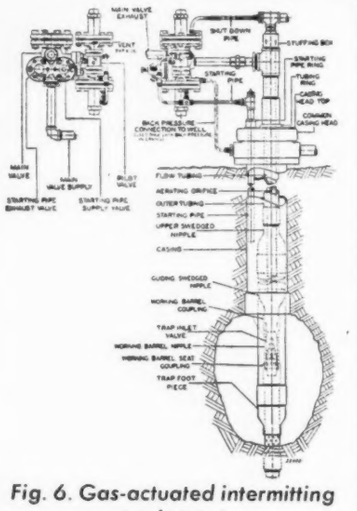


Fig. 6. Gas-actuated intermitting equipment

also by the method whereby the tubing is lifted from its seat to admit the gas. This method has been employed in California, Indiana, Kansas, Oklahoma, Texas, Arkansas, Louisiana, Argentina, Trinidad, and Venezuela.

When using the pilot tubing with the Max-i-flo valve, the admission of gas is dependent upon the rise of the fluid in the well that causes pressure to build up in the pilot tubing, and at a given point causes the surface valve to open and allows gas to enter the annular space between the two tubing strings. (Fig. 6.) When the wells are deep, it is not practicable to lower a pilot tubing in the well; therefore, a pressure tank is set up on the surface, and a very small stream of gas is allowed to enter the tank until the pressure has built up sufficiently high to cause the pilot valve to operate, thus allowing admission of gas to the annular space.

Type 4. Packer and valve. No chamber. (Closed type.)

Type 4 is similar in many respects to Type 2, except that a packer is run on the tubing to seal the annulus between the tubing and casing, thereby preventing the gas from passing around the end of the tubing. This type is employed when the fluid level is lower, or when the desired production is greater, than in Type 2, which would have a greater tendency to allow the gas to pass below the tubing string if no packer were used, thus resulting in the use of more input gas than necessary. Admission of gas is controlled by:

(a) Differential-pressure valve.
(b) Wire-line intermitter operating valve in tubing.
(c) Lifting the tubing intermittently.

These three gas admission controls are operated from the surface. The differential-pressure valve is controlled by a time-cycle intermitter on the surface; the wire-line intermitter from a cylinder and piston actuated by a time-cycle intermitter. Many installations of this type have been made in the Gulf Coast, Rodessa, East Texas, Ward County, Texas, and in various other places. Data on the operation of this type are given in Table 4[14].

This type of intermittent flow is employed in wells where the fluid level

Fig. 7. The bottom-hole intermitter on which data are presented in Table 5

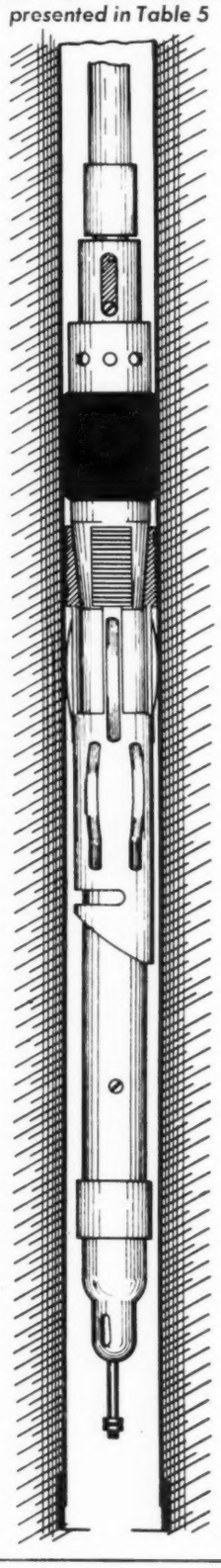


TABLE 4

Data on intermittent flow of Type 4 with packer and valve, without chamber

Well	Place	Casing diameter, in.	Tubing diameter, in.	Total depth, ft.	Operating depth, ft.	Depth packer set, ft.	Bbl. fluid per day	Cu. ft. gas per bbl. fluid	Cycles per day	Operating pressure, lb. per sq. in.
A	East Texas	5	2	3669	1620	3661	40	315	48	400
B	South Texas	8	2	2221	2185	2208	14	794	36	300
C	Kansas	7	2	3437	3356	3359	30	470	72	470
D	California	7	2½	6034	4192	5852	230	700	72	450
E	New Mexico	7	2	4910	4887	4900	35	800	72	400
F	North Louisiana	7	2½	6100	6022	6024	66	700	36	300
G	Texas	7	2½	8300	7965	8006	40	2100	48	400
H	California	7	2½	8900	8505	8568	150	2400	48	500

TABLE 5

Performance data on intermittent flow with the Clark bottom-hole intermitter, in the Oklahoma City field at depths of about 6500 ft.

Well	Bbl. per day	Cu. ft. input gas		Cycles per day	Pressures shut-in, lb. per sq. in.	Bbl. per cycle
		Per day	Per bbl.			
A	873	1,620,000	1,860	....	160	....
B	786	852,000	1,085	75	....	10.5
C	616	1,525,000	2,474	....	150	....
D	589	3,300,000	5,591	....	70	....
E	510	2,100,000	4,130	113	135	4.5
F	411	1,320,000	3,213	....	85	....
G	325	910,000	2,800	42	....	7.8
H	257	2,020,000	7,846	....	60	....
I	206	1,280,000	6,217	....	75	....
J	171	2,050,000	11,918	68	58	2.5
K	154	597,000	3,883	....	50	....
L	120	775,000	6,451	....	70	....
M	75	975,000	13,004	....	....	....
N	31	485,000	15,680	62	20	0.5
O	14	80,000	5,605	3	10	5.0

Fig. 8. Surface equipment on one type of wire-line intermitter

is sufficiently high that the daily allowable can be obtained without resorting to the use of a chamber.

Type 5. Intermittent flow with packer, chamber, and valve.

Type 5 is employed with low fluid levels when it is desired to lift the maximum quantity of oil with minimum expenditure of gas. A chamber is run on the end of a string of tubing with packer set between tubing and casing in order that the annular space may be employed as a gas reservoir, whereas in other cases the casing is employed as the eductor. When the casing is employed as the storage for gas, the gas admission valve is inserted above the packer as close to the top of the packer as possible, in order to reduce the escape of residual gas to a minimum. The gas admission valve is controlled by:

(a) Differential pressure
(b) Wire-line intermitter
(c) Lifting of the tubing
(d) Surface intermitter.

Similar to Type 4, the various subsurface intermitters are usually controlled by a surface intermitter of some sort, usually the time-cycle type. No data are at hand giving information on the performance of intermitters controlled by (a), (b), or (c). Data on the Clark bottom-hole intermitter (Fig. 7) obtained from the operation of a number of wells in the Oklahoma City field are as given in Table 5[16].

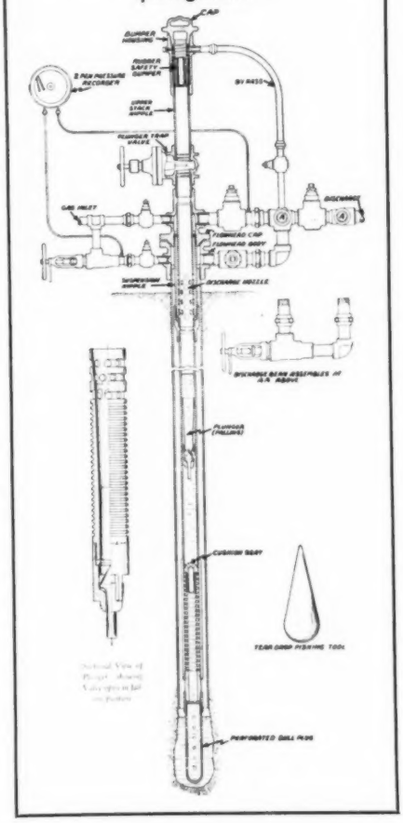
In a general way it may be seen that the quantity of input gas employed per day when using the Clark bottom-hole intermitter depends upon the number of barrels lifted per day; the quantity of gas per barrel being lower with the larger production. Daily rate of production depends principally upon the bottom-hole pressure; as the pressure declines, the rate of production is reduced. If the productivity of the well is high, however, and the allowable is small, the number of cycles per day will be reduced, and the input gas-factor per bbl. will be reduced in a given well, corresponding somewhat to the reduced number of cycles per day. Some 150 installations of the Clark bottom-hole intermitter were made in the Oklahoma City field at the time this method was being employed.

Some of the makers of intermitters that have been employed successfully in the Gulf Coast and other Texas fields are the Nixon surface-controlled gas-lift, the Jones-Stagg intermitter, (Fig. 8) and the Guiberson intermitter[17].

In all chambers and moving mechanisms in a well, trouble can arise from excessive quantities of sand entering the chamber, and valves become worn thus causing leaks, and necessitating pulling jobs. In this type when using the packer, and when considerable sand enters the well, some instances have occurred where the packer became stuck, and the tubing string was

[17] "Flow Valves in Gas-Lift," C. E. Tweedle. *International Oil*, April, 1940, p. 57.

Fig. 9. Details of one type of plunger lift



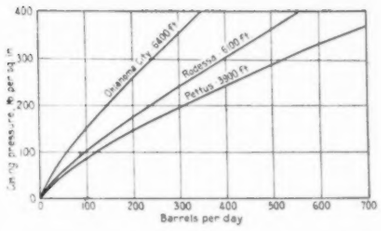


Fig. 10. Capacities of 2½-in. eductor using plunger lift

pulled apart when attempting to remove the equipment.

Where a packer is used, the escape of residual gas from the chamber may be somewhat slow in that it must await the discharge of the slug of oil from the tubing, thus reducing the number of cycles that may be employed during the 24 hours.

6. Plunger-lift.

The plunger-lift differs materially in action from all the preceding types mentioned. In this type of intermittent flow, the tubing is employed as the eductor, and is bored to a smooth surface, so that a closely fitting, valved plunger can pass down through the tubing, through the rising column of gas, and through the accumulated column of oil, to a cushion seat placed in the tubing close to the bottom. The valve in the bottom of the plunger is thrown up against its seat by striking the cushion seat so that the gas cannot pass up through the plunger. The gas behind the plunger lifts the plunger with its load of oil to the surface, and when the gas is discharged through the ports in the tubing under the plunger, the valve in the plunger drops out of its seat and the plunger drops to the bottom for another load of oil. (See Fig. 9.) The plunger-lift is employed in tubing of 2 in., 2½ in., 3 in., and 4 in.

The plunger-lift has been employed in Oklahoma City, Keokuk Falls, Crescent, Edmond, Rodessa, East Texas, Gulf Coast, West Texas, Dominguez, Coyote, Shiell's Canyon, Kettleman Hills, Roumania, Trinidad, and Venezuela. Examples of the use of the plunger-lift are given in Table 6.

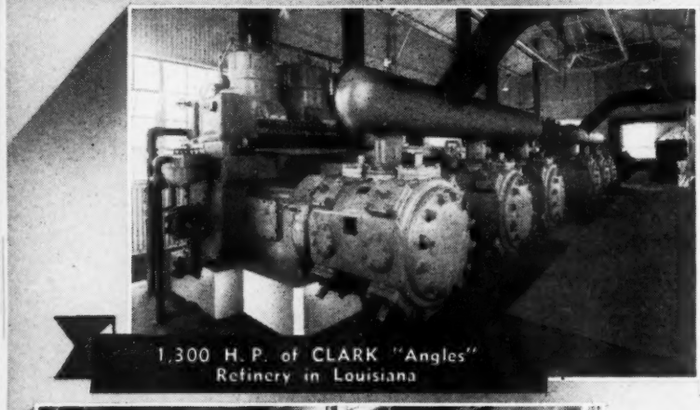
Capacities of various sizes of eductors used with the plunger-lift are shown in Figs. 10, 11, and 12.

The plunger-lift operates to advantage in wells where the reservoir pressure is fairly high and where the oil does not flow into the well in large quantities. It performs to better advantage when there are not excessive quantities of sand and paraffin present, and when there are not excessive quantities of sulphur gases especially when accompanied by salt water. The method

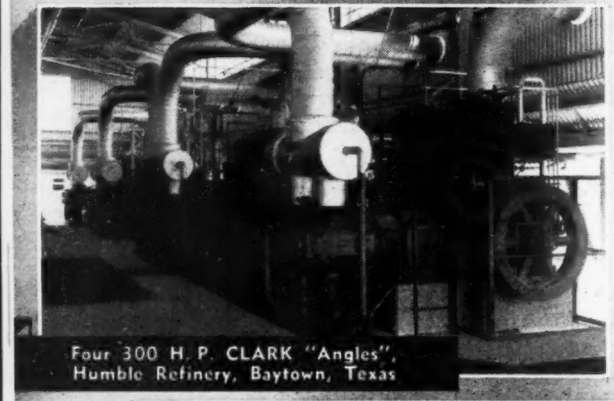
(Continued on Page 96)

111,900 H.P. OF CLARK Refinery

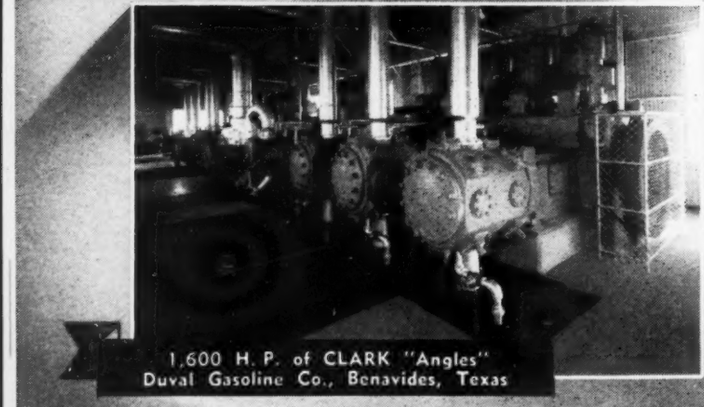
Three 400 H. P. CLARK "Angles"
Stanolind, Corpus Christi



1,300 H. P. of CLARK "Angles"
Refinery in Louisiana



Four 300 H. P. CLARK "Angles",
Humble Refinery, Baytown, Texas



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General Petroleum Corporation
Gulf Refining Company
Hanlon-Buchanan
Humble Oil & Refining Company
Latonia Refining Company
Magnolia Petroleum Company
Petroleos Mexicanos
Phillips Petroleum Company
Shamrock Oil & Gas Company
Shell Oil Company, Inc.
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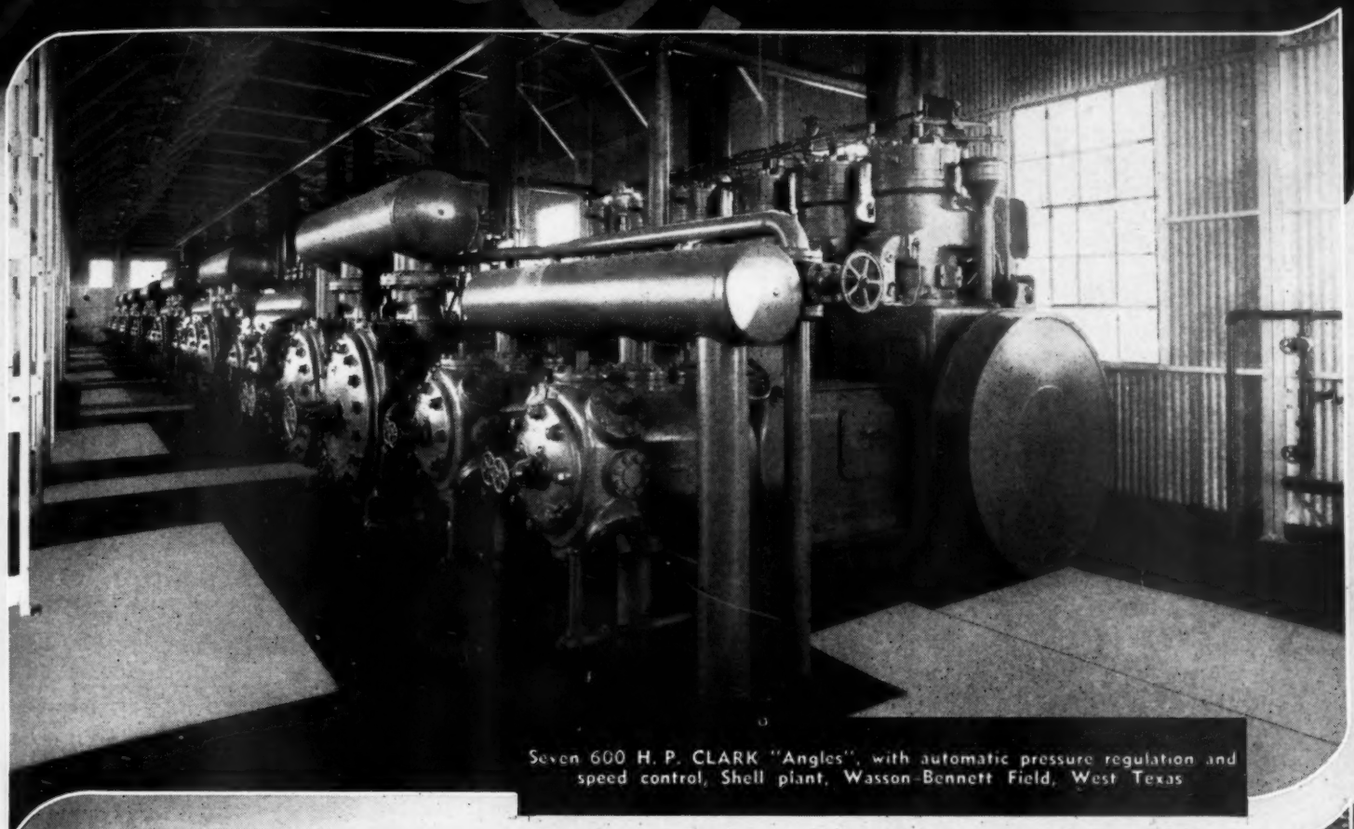
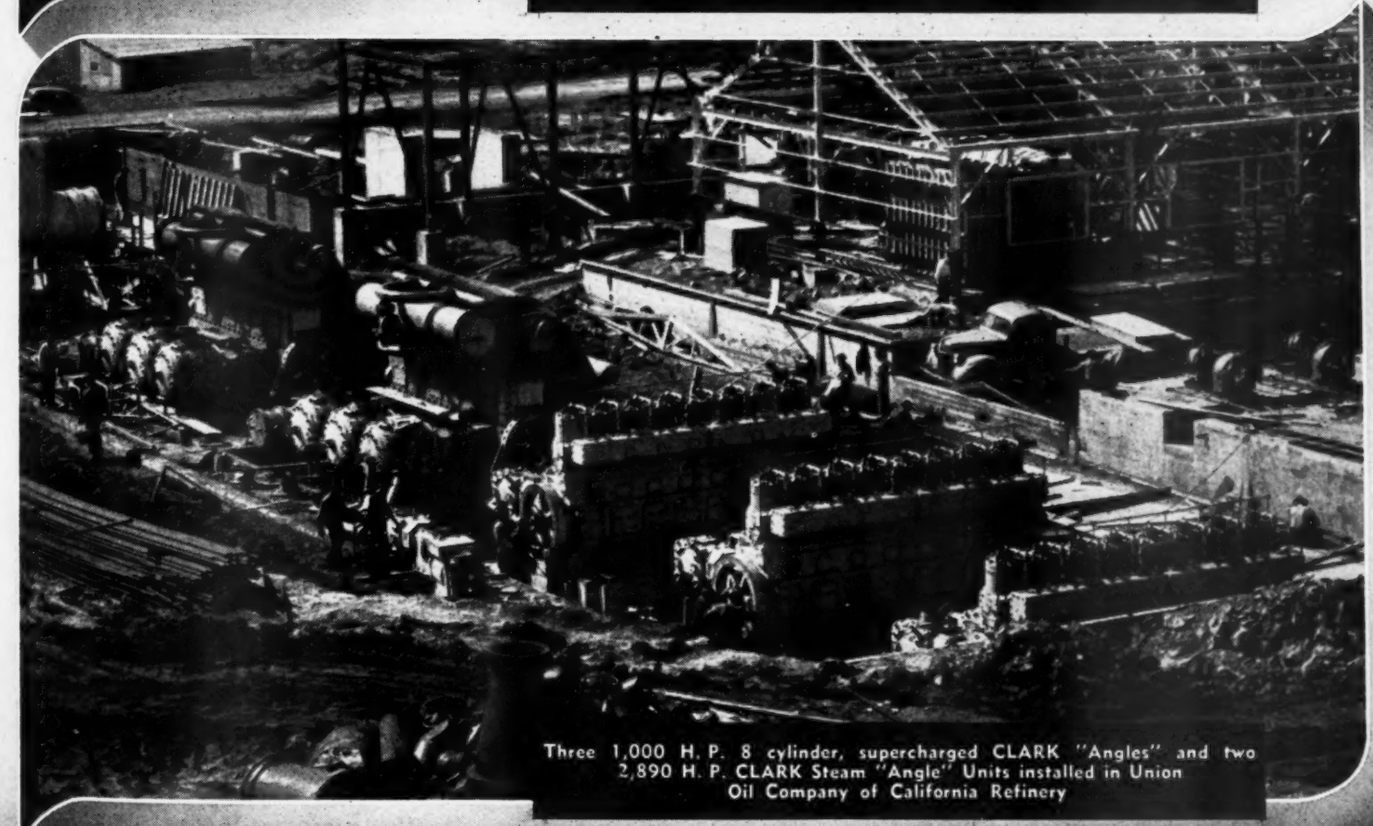


Seven 600 H. P. CLARK "Angles", with automatic pressure regulation and speed control, Shell plant, Wasson-Bennett Field, West Texas



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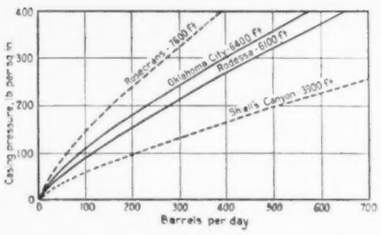

Fig. 11. Capacities of 3-in. eductor using plunger lift

(Continued from Page 93)

has handled considerable quantities of sand and paraffin in some fields, however, but would have operated to better advantage without these conditions.

Many wells have been flowed naturally with the plunger-lift, in which input gas was required with other gas-lift methods. In one case in the Oklahoma City field, a 90-hp. compressor operating normally with discharge pressure of about 100 lb. per sq. in., handled four wells on plunger-lift and had sufficient capacity for two or three

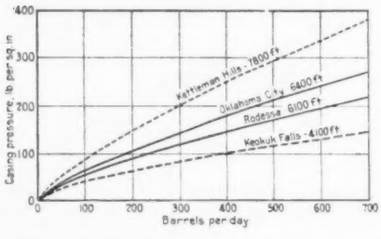
Casing pressure lb per sq in
Barrels per day
Kettleman Hills - 7800 Ft
Oklahoma City 6400 Ft
Rodessa 6100 Ft
Keokuk Falls - 4100 Ft

Fig. 12. Capacities of 4-in. eductor using plunger lift

more such wells. One of these wells, however, did not require input gas except when the well went down, and had to be restarted.

General Remarks

Surface injection of gas in intermittent flow does not necessarily require that a packer be set in the well, whereas injection from a point within the well usually includes the setting of a packer. With two tubing strings, as in Type 3, however, the admission of gas can be partly controlled by a valve operating on a differential pressure near the bottom of the well, and partly controlled by an intermitter on the surface.

When a packer is employed, the admission into the eductor may be made by means of a differentially-operated valve placed at a point close to the bottom of the well, or by means of a valve mechanically operated from the surface.

Each of the methods of positive control handled from the surface has its advantages and disadvantages. The wire-line method is less cumbersome and more easily operated than lifting of the tubing, but is not readily adaptable to the handling of more than one set of valves. The frequent breaks when wire lines were operated in salt water have been materially reduced by the use of improved stainless steel wire lines when operating in corrosive fluids.

The method of lifting and lowering the tubing for intermitting involves the handling of a heavy string of tubing many times per day and especially in a deep well may gradually develop weakness in the coupling threads and cause parting of the tubing. On the other hand, it may be made to handle more than one set of valves when such becomes necessary.

Advantages of intermittent flow, more particularly when fluid levels are low, are those of increased production over the use of continuous gas-lift flow, and the use of less input gas per barrel of oil lifted.

Disadvantages of intermittent flow are those of more complication than in straight gas-lift, and the necessity of using moving parts in a well that get out of order from time to time, and make a pulling job necessary.

TABLE 6

Performance data on the use of the plunger-lift

Well	Field	Total depth, ft.	Tubing diameter, in.	Bbl. lifted per day	Cu. ft. input gas per bbl.	Casing pressure, lb. per sq. in.
1	Kettleman Hills	8200	4	230	3830	265
2	Kettleman Hills	7770	4	531	1049	345
3	Oklahoma City	6570	4	413	2020	215
4	Oklahoma City	6410	4	77	7000	49
5	Rodessa, La.	....	4	195	995	80
6	Rodessa, La.	....	4	20	9613	23
7	Santa Fe Springs	6730	3	140	2000	102
8	Oklahoma City	6517	3	134	2760	136
9	Oklahoma City	6517	3	65	4590	67
10	Rodessa, La.	....	3	219	2960	225
11	Rodessa, La.	....	3	97	....	78
12	Dominguez, Cal.	5060	3	157	....	75
13	Dominguez, Cal.	5026	3	141	3680	165
14	Dominguez, Cal.	5365	3	43	1500	25
15	Shiell's Canyon	4002	3	113	1310	75
16	Shiell's Canyon	3877	3	38	2320	20
17	Ventura, Cal.	6302	2½	174	1290	300
18	Ventura, Cal.	6842	2½	89	1800	125
19	Oklahoma City	6546	2½	160	2695	....
20	Oklahoma City	6545	2½	17	....	48
21	Rodessa, La.	....	2½	154	2790	185
22	Rodessa, La.	....	2½	11	3600	25
23	Conroe	5159	2½	50	3280	90
24	Pettus	3934	2½	160	327	154
25	Pettus	3918	2½	25	1950	26
26	East Texas	2895	2½	132	632	86

P 094.6

When to Treat Oil Machinery Belts and Lubricate Bearings

by W. F. Schaphorst

TOO many oil men make the error of waiting for belts to slip before applying dressing or treatment. Then when they *do* apply dressing they are likely to apply so much that the belt will fail to pull properly for some time because of the interval required for the belt to absorb the dressing, especially if it is of the liquid type. I know of an instance where a 600-hp. engine was laid up for almost half a day because the engineer applied too much treatment to the belt while it was in use. It was only after much wiping and cleaning that the belt was brought to a good tractive condition.

When a belt is well filled with treatment, and when the surface is soft and pliable, it is at its best. The proper time to treat the belt is just before shutting down for the night (if it is a main drive belt). If the belt runs on a wrapper pulley or loose pulley part of the time, treat it when it is not working. The treatment will then have ample time to "soak in."

As for oiling bearings, oil them at the end of the day also while they are yet warm. Just after shutting down is the best time. A thin film of oil is thus inserted between the bearing and shaft when starting time comes, and starting will be easier. A film does not form so easily on cold bearings. To be sure, this does not apply to bearings that are automatically and continuously lubricated. Bearings of this latter class are "all right" all the time—provided the lubricant is all right and provided the automatic lubricating system is in proper working order.

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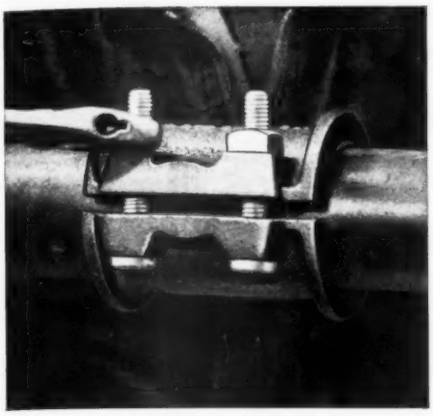

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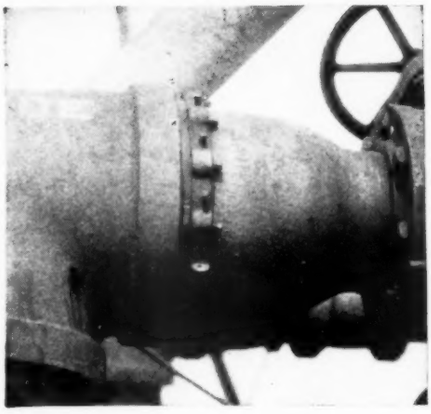

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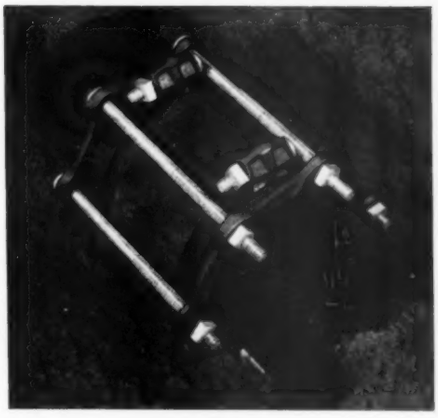

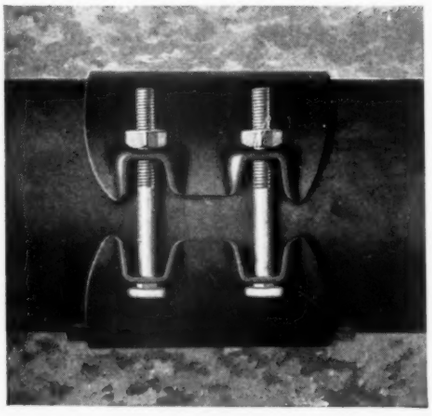

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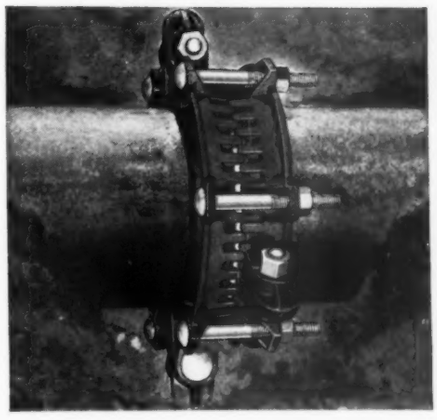

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Practical Suggestions for Improving Quality of Crude Oil

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☆ Reduction in paraffin and sludge content and conservation of vapors are among factors discussed

by F. R. Cozzens

District Field Manager, Equity Oil and Gas Company

IN the conservation of gasoline, naphtha, and numerous other petroleum products, now deemed necessary as a defense measure, producers can do both the industry and themselves a patriotic turn by improving the quality of the crude oil that goes into the lines. It is not generally known that the value of crude oil can be altered materially by local conditions, once it has been classified according to gravity tests, but experiments recently conducted under modern refining methods have shown that gravity can be influenced as much as 10 points by improper storage, and that a producer may be shipping oil worth 50 cents more per bbl. than that of his neighbor with the same grade who happens to be careless about storage. This cash difference doesn't reach the producer's pocket, however, but goes to build the poor oil to specifications. Such fluctuations are being closely studied in many fields, and producers are preparing for a time when the selling price of crude oil will be determined by the quality at the wells instead of by a classified grade in the lines.

In the eastern stripper fields where air pressure has long been used as a recovery measure almost 70 percent of the oil has a high content of paraffin and sludge, much of which is passed into the carrying lines by careless producers, especially in summer. Such oil can be greatly improved in quality, and at slight cost to the producer, by heating the tanks when nearly full to a temperature of 110° to 115°F., for a period of 24 hr. The residue is then drawn-off through the water tap. If, during the heating process, scum appears on the oil, a sprinkling of soap chips over the surface tends to sink the residue to the bottom of the tank where it is easily withdrawn.

In areas where salt-water is prevalent, encrustations form rapidly inside the tanks and in the lines conveying oil from them. Flakes of this material constantly pass unnoticed into storage oil and often cause a troublesome condition at the refinery. A similar condition is common in localities where sulphur and various mineral oxides are drawn into an oil sand. Chemicals for the removal of these agents are beyond the scope of the average producer, but the damage can be greatly reduced by a frequent cleaning of the tanks and lines, and by swabbing with a solution consisting of 20 lb. of common baking soda to 1 bbl. of boiling water. As mineral oxides are corrosive, leaks in the bottom of a storage tank are often discovered during the cleaning process. Careless producers generally check such leaks by dumping a quantity of earth upon the floor of an empty tank, unmindful of the fact that certain types of clay are readily dissolved in oil, resulting in extra cost involved in removing it at the refinery.

F. R. COZZENS

was born October 10, 1895, near Marietta, Ohio—Five years later occurred the pioneer oil boom of the area, discovery of the Marietta-Macksburg field—Since then he has lived and worked virtually in the shadow of oil derricks—Became a roustabout in the Marietta-Macksburg field at the age of 16, and has since served as tool dresser, pumper, lease hound, and contractor—In 1935 he helped organize local interests into the company that is known as the Equity Oil and Gas Company, of which he is district manager—Lives at Stockport, Ohio.

Another common practice among numerous small producers is to hold oil in storage on the lease during long periods of time. Evaporation under average conditions tends to thicken the oil to a degree where, if passed into conveying lines with thin oil, a sufficient number of globules will form to carry along paraffin, water, and sludge. Rust and scales are also conveyed in this manner, causing results similar to mineral oxides. All such oil should be heated in the tanks and stirred vigorously before shipping. When oil must be stored on the lease, the careful operator sees to it that vents are kept closed and evaporation lessened in every possible way. He is likewise careful that temperature does not reach the boiling point during any heating process, and that chilled oil is not introduced while heating is being done. As atmospheric conditions are damaging to crude oil the modern operator provides covers for drip barrels and tanks, and arranges lines to exclude air. Forcing natural gas in slight amounts under pressure through lines and storage tanks livens oil and improves quality.

These, and various other conditions common to most localities are now being closely checked by producers, and in more than 80 percent of the cases an improvement in oil quality results. In several areas in the Ohio-Pennsylvania fields, a quality improvement was made, under tests, of 10 to 20 percent, at no increase in production costs. Producers therefore receive cash dividends indirectly through greater efficiency and more rapid processing, and so put their business into condition to meet future industrial requirements.

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A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT No. 51

THE tables on the following pages are designed to save time and effort for the technician, and to assist the practical field or plant worker to solve problems commonly encountered in routine work. They are not intended nor expected to supplant technical training and make every man his own designer. Most of the tables can be understood and applied by anyone acquainted with the simple fundamentals of mathematics.

For the convenience of readers who wish to refer to the tables, each page carries in the upper right corner an index number that classifies the table according to subject matter.

All petroleum engineering literature may be indexed for reference according to the Dewey Decimal System as modified and extended for the petroleum industry by L. C. Uren, professor of petroleum engineering at the University of California. When classified according to these index numbers the material follows in a logical sequence and falls into several natural divisions, as illustrated by the following outline:

Nos. P000-P339—General
Nos. P400-P499—Drilling
Nos. P500-P599—Production
Nos. P600-P699—Transportation and Storage (includes Pipe Line)
Nos. P700-P799—Refining, including
Nos. P770-P779—Natural Gasoline, which may be classified in a separate division (as shown here) if of special interest to the user

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To aid the reader in using the Decimal System, a subject index arranged alphabetically has been published, and is available at a cost of 50 cents per copy from *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

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Rise in fluid level, etc., due to running 2-in. non-upset tubing in well fluid		P 511.141.202.	105	Sept.
Rise in fluid level, etc., due to running 2½-in. external-upset tubing in well fluid		P 511.141.250.1	89	Aug.
Rise in fluid level, etc., due to running 2½-in. non-upset tubing in well fluid		P 511.141.252.	107	Sept.
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Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.350.1	91	Aug.
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*This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-14, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue, and 37-48, inclusive, in the June, 1941, issue.

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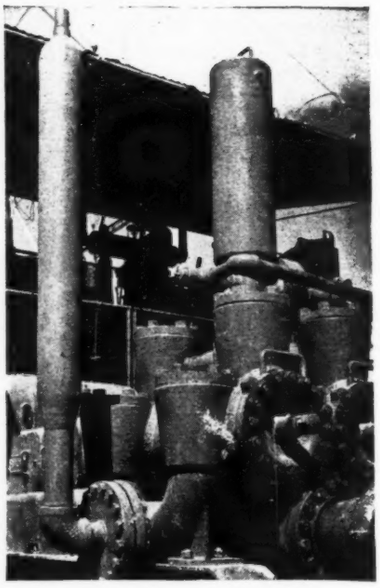
VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH ANNULUS BETWEEN 2-IN. AND 3½-IN. TUBING

Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	1000	16.9	6.3	3.9	2.8	2.2	1.9	1.6	1.5	1.2
100		33.7	12.5	7.8	5.7	4.5	3.7	3.2	3.0	2.5
150		50.6	18.8	11.7	8.5	6.7	5.6	4.8	4.5	3.7
200		67.5	25.1	15.6	11.4	9.0	7.4	6.4	6.0	5.0
250		84.4	31.3	19.5	14.2	11.2	9.3	7.9	7.5	6.2
300		101.2	37.6	23.4	17.0	13.4	11.1	9.5	9.0	7.5
350		118.1	43.9	27.3	19.9	15.7	13.0	11.1	10.5	8.9
400		135.0	50.1	31.1	22.7	17.9	14.9	12.7	12.0	9.9
50	1250	20.7	7.8	5.3	3.5	2.8	2.3	2.0	1.9	1.5
100		41.4	15.6	10.6	7.0	5.6	4.6	3.9	3.7	3.1
150		62.0	23.4	15.8	10.6	8.3	6.9	5.9	5.6	4.6
200		82.7	31.3	21.1	14.1	11.1	9.2	7.9	7.4	6.1
250		103.4	39.1	26.4	17.6	13.9	11.5	9.8	9.3	7.6
300		124.1	46.9	31.7	21.1	16.7	13.8	11.8	11.1	9.2
350		144.7	54.7	37.0	24.7	19.4	16.1	13.8	13.0	10.7
400		165.4	62.5	42.3	28.2	22.2	18.4	15.7	14.9	12.2
50	1500	24.9	9.4	5.8	4.2	3.3	2.7	2.3	2.0	1.8
100		49.9	18.7	11.6	8.4	6.6	5.6	4.7	4.1	3.6
150		74.8	28.1	17.4	12.6	9.9	8.2	7.0	6.1	5.4
200		99.8	37.4	23.2	16.8	13.3	11.0	9.4	8.2	7.3
250		124.7	46.8	29.0	21.0	16.6	13.7	11.7	10.2	9.1
300		149.6	56.1	34.8	25.3	19.9	16.4	14.0	12.3	10.9
350		174.6	65.5	40.6	29.5	23.2	19.2	16.4	14.3	12.7
400		199.5	74.8	46.4	33.7	26.5	21.9	18.7	16.4	14.5
50	1750	28.9	10.9	6.7	4.9	3.9	3.2	2.7	2.6	2.1
100		57.8	21.8	13.5	9.8	7.7	6.4	5.4	5.1	4.2
150		86.7	32.7	20.2	14.7	11.6	9.5	8.1	7.7	6.3
200		115.7	43.6	27.0	19.6	15.4	12.7	10.9	10.3	8.4
250		144.6	54.5	33.7	24.5	19.3	15.9	13.6	12.8	10.5
300		173.5	65.4	40.5	29.4	23.1	19.1	16.3	15.4	12.6
350		202.4	76.3	47.2	34.3	27.0	22.3	19.0	17.9	14.7
400		231.3	87.2	54.0	39.2	30.8	25.4	21.7	20.5	16.8
50	2000	33.0	12.4	7.7	5.6	4.4	3.6	3.1	2.8	2.4
100		66.0	24.9	15.4	11.2	8.8	7.2	6.2	5.5	4.8
150		99.1	37.3	23.1	16.7	13.2	10.9	9.3	8.3	7.2
200		132.1	49.8	30.8	22.3	17.6	14.5	12.3	11.0	9.6
250		165.2	62.2	38.5	27.9	21.9	18.1	15.4	13.8	12.0
300		198.2	74.7	46.2	33.5	26.3	21.7	18.5	16.5	14.3
350		231.2	87.1	53.9	39.1	30.7	25.4	21.6	19.3	16.7
400		264.2	99.6	61.6	44.7	35.1	29.0	24.7	22.0	19.1
50	2250	37.1	14.0	8.6	6.3	4.9	4.1	3.5	3.3	2.7
100		74.3	28.0	17.3	12.5	9.9	8.1	6.9	6.5	5.4
150		111.4	42.0	25.9	18.8	14.8	12.2	10.4	9.8	8.0
200		148.6	56.0	34.6	25.1	19.7	16.3	13.8	13.1	10.7
250		185.7	70.0	43.2	31.3	24.6	20.3	17.3	16.3	13.4
300		222.9	83.9	51.9	37.6	29.6	24.4	20.8	19.6	16.1
350		260.0	98.0	60.5	43.9	34.5	28.4	24.2	22.9	18.7
100		297.2	111.9	69.2	50.1	39.4	32.5	27.7	26.1	21.4
50	2500	41.3	15.5	9.6	7.0	5.5	4.5	3.8	3.6	3.0
100		82.5	31.0	19.2	13.9	10.9	9.0	7.7	7.2	5.9
150		123.8	46.6	28.8	20.9	16.4	13.5	11.5	10.9	8.9
200		165.1	62.1	38.4	27.8	21.9	18.0	15.3	14.5	11.9
250		206.3	77.7	48.0	34.8	27.3	22.5	19.2	18.1	14.8
300		247.6	93.2	57.6	41.7	32.8	27.0	23.0	21.7	17.8
350		288.9	108.7	67.2	48.7	38.2	31.5	26.8	25.3	20.8
400		330.1	124.3	76.8	55.6	43.7	36.0	30.7	29.0	23.7

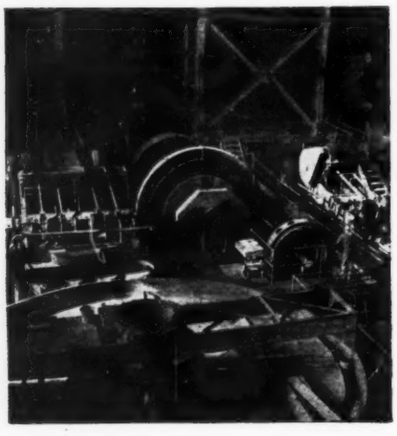
[1]Solution of gas and condensation under pressure are not considered; hence the values are maxima.
[2]Gas volumes entering into velocity calculations are based on tubinghead pressure; atmospheric pressure is assumed to be 15 lb. per sq. in. in calculating the number of atmospheres.

IN THE NEWS
WITH BANTAM BEARINGS

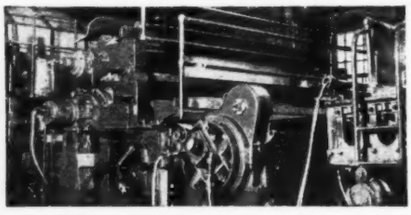
WATCHER OF THE SKIES in the nation's defense, the first of the new Bofors 40-millimeter mobile anti-aircraft guns rolled out of the plant of The Firestone Tire & Rubber Company weeks ahead of schedule, with General Charles T. Harris and John W. Thomas, president of Firestone, at the controls. For this newest defense weapon, Bantam supplies special double-direction thrust bearings on which the gun units turn—another instance of Bantam's skill in the manufacture of bearings for unique engineering requirements.



OIL FIELD PUMPS ARE WORKING day and night to keep pace with the constantly growing demand for petroleum products. Typical of the progressive design that enables the pumps to withstand twenty-four hour heavy-duty service is the 7½ x 14 power pump built by Emsco Derrick & Equipment Company. A specially designed Bantam Straight Radial Roller Bearing, 20" I.D. x 25" O.D. x 3" wide is used on the eccentric.



FINE GRINDING is an extremely exacting job in this cement mill installation of equipment built by The Dorr Company, Incorporated. This particular unit is used to convert 1-inch stone into fine powder. Other Dorr Classifiers are playing an important part in preparing ores for treatment by metallurgical processes. On many of the Dorr Classifiers—particularly on larger models for heavy duty—Bantam Ball Bearings are now standard for the eccentric strap.



IN HIGH-SPEED PAPER MACHINERY, Bantam Bearings of many types find wide application. Bantam Mill Type Bearings are used in this suction press roll built by Beloit Iron Works for a leading paper mill. Bearings of this type are also extensively used in steel mill and rubber mill machinery.

BANTAM'S ENGINEERING SKILL and cooperation with machine builders give added assurance of satisfactory bearing performance. Bantam engineers, with wide experience in the performance of every major type of anti-friction bearing, will select or design the bearing that best meets your needs. For *better* machines, more and more manufacturers TURN TO BANTAM for their bearing requirements.

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

RISE IN FLUID LEVEL, ETC., DUE TO RUNNING 2-IN. NON-UPSET TUBING IN WELL FLUID

Diameter of outer string or open hole, in.	Internal diameter of outer string or open hole, in.	Volume[1] contained in outer string or open hole		Volume[1] contained in annular space		Volume[1] in well bore when tubing is in hole (volume in annulus plus volume in tubing)		For every 100 ft. of tubing run in fluid, fluid level will be raised:	
		gal.	bbl.	gal.	bbl.	gal.	bbl.	in annular space when lower end of tubing is closed, ft.-in.	in well bore when lower end of tubing is open, ft.-in.
Tubing strings Non-upset									
3½	3.584	51.36	1.223	28.15	0.6702	44.39	1.057	82- 5	15- 6
4	3.958	63.92	1.522	40.71	.9693	56.95	1.356	57- 0	12- 1
Upset									
3½	3.476	49.30	1.174	26.09	.6212	42.33	1.008	88-11	16- 3
4	3.958	63.92	1.522	40.71	.9693	56.95	1.356	57- 0	12- 1
Casing strings[2]									
4½	4.090	68.25	1.625	45.04	1.072	61.28	1.459	51- 6	11- 3
4½	3.920	62.69	1.493	39.48	0.940	55.72	1.327	58- 9	12- 4
5	4.560	84.84	2.020	61.63	1.467	77.87	1.854	37- 4	8-10
5	4.276	74.60	1.776	51.39	1.224	67.63	1.610	45- 1	10- 1
5½	5.044	103.8	2.471	80.59	1.919	96.83	2.305	28-10	7- 1
5½	4.670	88.98	2.119	65.77	1.566	81.01	1.929	35- 3	8- 6
6	5.524	124.5	2.964	101.3	2.412	117.5	2.798	22-11	5-10
6	5.240	112.0	2.667	88.79	2.114	107.0	2.548	26- 1	6- 5
6⅝	6.135	153.6	3.657	130.4	3.105	146.6	3.490	17-10	4- 8
6⅝	5.675	131.4	3.129	108.2	2.576	124.4	2.962	21- 6	5- 6
7	6.538	174.4	4.152	151.2	3.600	167.4	3.986	15- 4	4- 1
7	5.920	143.0	3.405	119.8	2.852	136.0	3.238	19- 4	5- 1
7⅝	7.125	207.1	4.931	183.9	4.379	200.1	4.764	12- 7	3- 5
7⅝	6.625	179.1	4.624	155.9	3.712	172.1	4.098	14-11	4- 0
8⅝	8.097	267.5	6.369	244.3	5.817	260.5	6.202	9- 6	2- 8
8⅝	7.511	230.2	5.481	207.0	5.929	222.3	5.293	11- 3	3- 2
9⅝	9.063	335.1	7.979	311.9	7.426	328.1	7.812	7- 5	2- 1
9⅝	8.535	297.2	7.076	274.0	6.524	290.2	6.910	8- 6	2- 3
10¾	10.192	423.8	10.09	400.6	9.538	416.8	9.924	5-10	1- 8
10¾	9.760	388.7	9.255	365 5	8.702	381.7	9.088	6- 4	1-10
11¾	11.150	507.2	12.08	484.0	11.52	500.2	11.91	4-10	1- 5
11¾	10.772	473.4	11.27	450.2	10.72	466.4	11.10	5- 1	1- 6
13⅜	12.715	659.6	15.71	636.4	15.15	652.6	15.54	3- 7	1- 1
13⅜	12.347	622.0	14.81	598.8	14.26	615.0	14.64	3-11	1- 2
Open hole (bit size)[3]									
3⅞	3.875	61.27	1.459	38.06	0.9062	54.30	1.293	61- 0	12- 8
4¼	4.250	73.70	1.755	50.49	1.202	66.73	1.589	46- 0	10- 4
4¾	4.750	92.06	2.192	68.85	1.639	85.09	2.026	33- 9	8- 1
5⅝	5.625	131.4	3.129	108.2	2.576	124.4	2.962	21- 5	5- 6
6	6.000	146.9	3.498	123.7	2.945	139.9	3.331	18- 9	4-11
6⅛	6.125	153.1	3.645	129.9	3.093	146.1	3.479	17-10	4- 9
6½	6.500	172.4	4.105	149.3	3.555	165.5	3.940	15- 7	4- 2
6¾	6.750	185.9	4.426	162.7	3.874	178.9	4.260	14- 3	3-10
7	7.000	199.9	4.760	176.7	4.207	192.9	4.593	13- 1	3- 7
7½[4]	7.500	229.5	5.464	206.3	4.912	222.5	5.298	11- 3	3- 1
7¾[4]	7.750	245.1	5.836	221.9	5.283	238.1	5.669	10- 6	2-11
8½[4]	8.500	294.8	7.019	271.6	6.467	287.8	6.852	8- 6	2- 5
9¾[4]	9.750	387.9	9.236	364.7	8.683	380.9	9.069	6- 4	1-10
10⅝	10.625	460.6	10.97	437.4	10.41	453.6	10.800	5- 4	1- 6

The 2-in. non-upset tubing has a calculated weight of 4.51 lb. per ft. (including a coupling spaced every 20 ft.). The volume displaced by 100 ft. of tubing and 5 couplings: (1) by the steel itself (with lower end of tubing open), 6.892 gal. or 0.16410 bbl.; (2) by the pipe (with lower end of tubing closed), 23.21 gal. or 0.5525 bbl. The volume contained within 100 ft. of the tubing is 16.238 gal. or 0.3866 bbl.

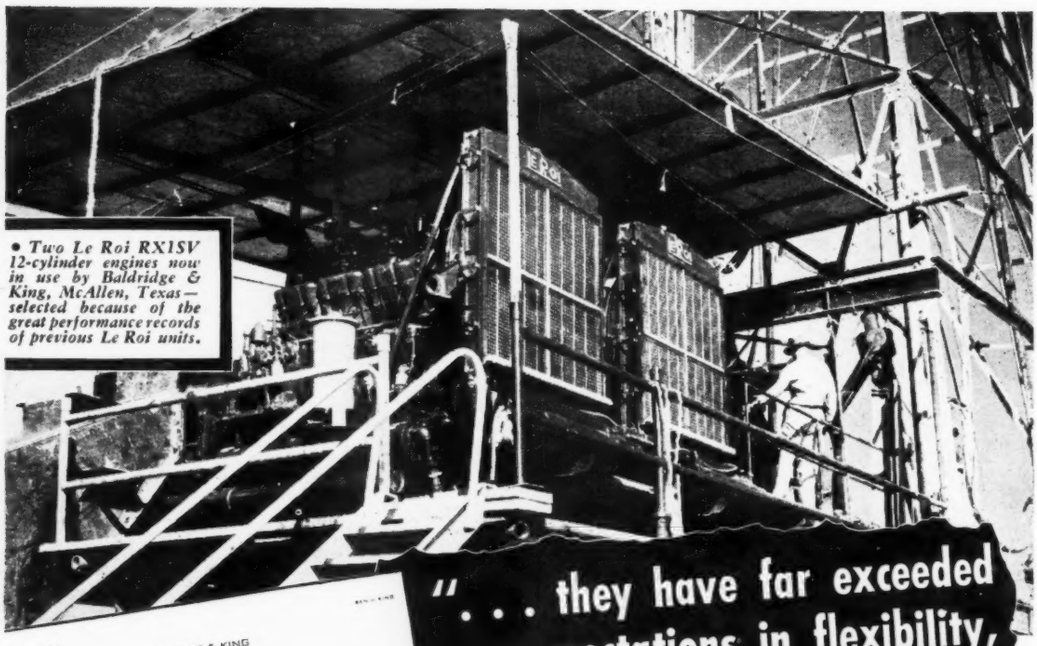
[1]All volume figures are based on 100 ft. of depth; multiply to convert to other depths or lengths. For example, if the depth or length is 5196 ft., multiply by 51.96.

[2]Only maximum and minimum weights of pipe are shown for each casing size.

[3]Variation in diameter of open hole due to caving, etc., is disregarded.

[4]This diameter is an average of the two bit sizes ⅛ in. larger and smaller, respectively.

Table suggested by George B. Rice, Butler & Horne Drilling Co., Dallas, Texas.



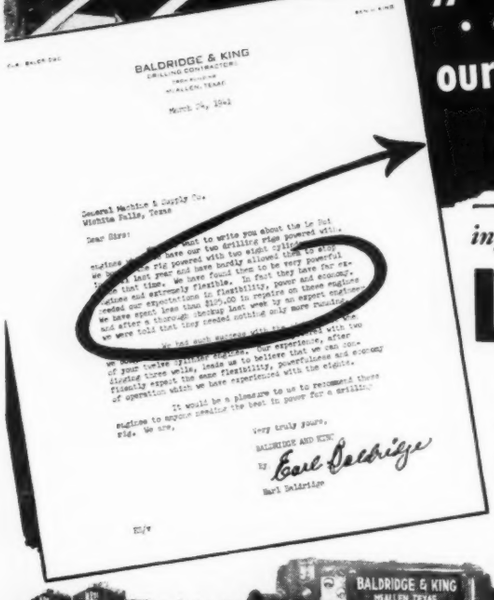
• *Two Le Roi RX1SV 12-cylinder engines now in use by Baldridge & King, McAllen, Texas — selected because of the great performance records of previous Le Roi units.*

"... they have far exceeded our expectations in flexibility, power, and economy"

— that's how Baldridge & King, Texas drilling contractors, sum up their experience with

LE ROI Drilling Engines

Gasoline — Natural Gas — Butane



BALDRIDGE & KING
DRILLING CONTRACTORS
McALLEN, TEXAS

March 24, 1941

General Machine & Supply Co.
Wichita Falls, Texas

Dear Sirs:

... want to write you about the Le Roi ... have our two drilling rigs powered with ... we ... rig powered with two eight cylinder units ... last year and have hardly allowed them to stop ... that time. We have found them to be very powerful ... and extremely flexible. In fact they have far ex... our expectations in flexibility, power and economy. ... exceed our expectations in fuel consumption. Since ... we have spent less than $175.00 in repairs on these engines ... and after a thorough checkup last week by an expert engine ... we were told that they needed nothing only more running ...

... We had such success with the ... of your twelve cylinder engines, our experience, after ... during three weeks, leads us to believe that we can con... financially expect the same flexibility, powerfulness and economy of operation which we have experienced with the eights.

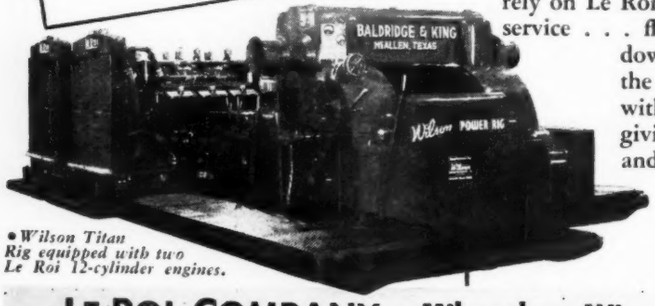
It would be a pleasure to us to recommend these engines to anyone wanting the best in power for a drilling rig. We are,

Very truly yours,
BALDRIDGE AND KING
By Earl Baldridge
Earl Baldridge

EB/v

Here's another case where careful engineering based on long experience with oil-field conditions — and rugged construction to exceptional precision standards — make Le Roi power "pay out" on one tough job after another. And it shows what many other successful contractors know — that you can rely on Le Roi for low-cost, long-life, trouble-free service . . . flashing power that doesn't let you down . . . and fuel bills that are easy on the cost sheets. Power *your* drilling rigs with Le Rois. Write for bulletin DE4 giving complete information on 4-, 6-, 8-, and 12-cylinder Le Roi Drilling Engines.

P-8



• *Wilson Titan Rig equipped with two Le Roi 12-cylinder engines.*

LE ROI COMPANY • Milwaukee, Wis. • Tulsa, Okla.

General Machine & Supply Company, Wichita Falls — Odessa, Texas
Southern Engine & Pump Company, Houston — Dallas — Kilgore, Texas
Western Machinery Company, St. Louis, Missouri • Salem, Illinois

RISE IN FLUID LEVEL, ETC., DUE TO RUNNING 2½-IN. NON-UPSET TUBING IN WELL FLUID

Diameter of outer string or open hole, in.	Internal diameter of outer string or open hole, in.	Volume[1] contained in outer string or open hole		Volume[1] contained in annular space		Volume[1] in well bore when tubing is in hole (volume in annulus plus volume in tubing)		For every 100 ft. of tubing run in fluid, fluid level will be raised:	
		gal.	bbl.	gal.	bbl.	gal.	bbl.	in annular space when lower end of tubing is closed, ft.-in.	in well bore when lower end of tubing is open, ft.-in.
Casing strings[2]									
4½	4.090	68.25	1.625	34.18	0.814	58.49	1.393	99– 8	16– 6
5	4.560	84.84	2.020	50.77	1.209	75.08	1.788	67– 1	12–10
5	4.276	74.60	1.776	40.53	0.965	64.84	1.544	84– 1	14–11
5½	5.044	103.8	2.471	69.73	1.660	94.04	2.239	48–10	10– 3
5½	4.670	88.98	2.119	54.91	1.307	79.22	1.886	62– 1	12– 2
6	5.524	124.5	2.964	90.43	2.153	114.7	2.731	37– 8	8– 5
6	5.240	112.0	2.667	77.93	1.855	102.2	2.433	43– 9	9– 5
6⅝	6.135	153.6	3.657	118.5	2.821	142.8	3.400	28– 9	6– 9
6⅝	5.675	131.4	3.129	97.33	2.317	121.6	2.895	35– 0	7–11
7	6.538	174.4	4.152	140.3	3.340	164.6	3.919	24– 3	5–10
7	5.920	143.0	3.405	108.9	2.593	133.2	3.171	31– 3	7– 3
7⅝	7.125	207.1	4.931	173.0	4.119	197.3	4.698	19– 8	4–11
7⅝	6.625	179.1	4.624	145.0	3.452	169.3	4.031	23– 6	5– 8
8⅝	8.097	267.5	6.369	233.4	5.557	257.7	6.136	14– 7	3– 9
8⅝	7.511	230.2	5.481	196.1	4.669	220.4	5.248	17– 4	4– 5
9⅝	9.063	335.1	7.979	301.0	7.167	325.3	7.745	11– 4	3– 0
9⅝	8.535	297.2	7.076	263.1	6.264	287.4	6.843	12–11	3– 4
10¾	10.192	423.8	10.09	389.7	9.279	413.0	9.833	8– 9	2– 5
10¾	9.760	388.7	9.255	354.6	8.443	378.9	9.021	9– 7	2– 7
11¾	11.150	507.2	12.08	473.1	11.264	497.4	11.843	7– 2	1–11
11¾	10.772	473.4	11.27	439.3	10.460	463.6	11.038	7– 9	2– 1
13⅜	12.715	659.6	15.71	625.5	14.893	649.8	15.471	5– 5	1– 6
13⅜	12.347	622.0	14.81	587.9	13.998	612.2	14.576	5–10	1– 7
Open hole (bit size)[3]									
4¼	4.250	73.70	1.755	39.63	0.944	63.94	1.522	86– 0	15– 1
4¾	4.750	92.06	2.192	57.99	1.381	82.30	1.960	58– 9	11– 9
5⅝	5.625	131.4	3.129	97.33	2.317	121.6	2.895	35– 0	7–11
6	6.000	146.9	3.498	112.8	2.686	137.1	3.264	30– 2	7– 1
6⅛	6.125	153.1	3.645	119.0	2.833	143.3	3.412	28– 8	6– 9
6½	6.500	172.4	4.105	138.3	3.293	162.6	3.871	24– 8	5–11
6¾	6.750	185.9	4.426	151.8	3.614	176.1	4.193	22– 5	5– 6
7	7.000	199.9	4.760	165.8	3.948	190.1	4.526	20– 7	5– 1
7½[4]	7.500	229.5	5.464	195.4	4.652	219.7	5.231	17– 5	4– 5
7¾[4]	7.750	245.1	5.836	211.0	5.024	235.3	5.602	16– 2	4– 1
8½[4]	8.500	294.8	7.019	260.7	6.207	285.0	6.786	13– 1	3– 5
9¾[4]	9.750	387.9	9.236	353.8	8.424	378.1	9.002	9– 9	2– 7
10⅝	10.625	460.6	10.97	426.5	10.155	450.8	10.733	8– 0	2– 2

The 2½-in. non-upset tubing has a calculated weight of 6.32 lb. per ft. (including a coupling spaced every 20 ft.). The volume displaced by 100 ft. of tubing and 5 couplings: (1) by the steel itself (with lower end of tubing open), 9.657 gal. or 0.2299 bbl.; (2) by the pipe (with lower end of tubing closed), 34.07 gal. or 0.8112 bbl. The volume contained within 100 ft. of the tubing is 24.309 gal. or 0.5788 bbl.

[1]All volume figures are based on 100 ft. of depth; multiply to convert to other depths or lengths. For example, if the depth or length is 5196 ft., multiply by 51.96.

[2]Only maximum and minimum weights of pipe are shown for each casing size.

[3]Variation in diameter of open hole due to caving, etc., is disregarded.

[4]This diameter is an average of the two bit sizes ⅛ in. larger and smaller, respectively.

Table suggested by George B. Rice, Butler & Horne Drilling Co., Dallas, Texas.

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GRAVITY OF DRY OIL IN OIL-WATER MIXTURES, DEG. A.P.I.

Gravity of "wet" oil, deg. A.P.I.	Percent water in mixture									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
40.0	40.03	40.06	40.10	40.14	40.18	40.21	40.25	40.29	40.33	40.36
.1	.13	.17	.21	.24	.28	.32	.36	.39	.43	.47
.2	.23	.27	.31	.35	.39	.42	.46	.50	.53	.57
.3	.34	.38	.42	.45	.49	.53	.57	.60	.64	.68
.4	.44	.48	.52	.55	.59	.63	.67	.71	.75	.78
40.5	40.53	40.56	40.61	40.64	40.68	40.72	40.76	40.79	40.83	40.87
.6	.61	.65	.69	.73	.77	.80	.84	.88	.92	.95
.7	.74	.77	.82	.85	.89	.93	.97	**41.00**	41.04	41.08
.8	.84	.88	.92	.96	.90	41.03	41.07	.11	.15	.19
.9	.93	.96	41.01	41.04	41.08	.12	.16	.20	.23	.27
41.0	41.03	41.07	41.11	41.15	41.19	41.23	41.26	41.30	41.34	41.38
.1	.14	.17	.22	.25	.29	.33	.37	.41	.45	.49
.2	.24	.28	.32	.36	.40	.44	.48	.52	.55	.59
.3	.33	.36	.41	.45	.49	.52	.56	.60	.64	.68
.4	.43	.47	.51	.55	.59	.63	.67	.71	.75	.79
41.5	41.54	41.58	41.62	41.66	41.70	41.74	41.78	41.81	41.85	41.89
.6	.64	.68	.73	.76	.80	.84	.88	.92	.96	**42.00**
.7	.73	.74	.81	.85	.89	.93	.97	42.01	42.05	.09
.8	.83	.87	.92	.95	**42.00**	42.04	42.08	.11	.15	.19
.9	.94	.98	42.02	42.06	.10	.14	.18	.22	.26	.30
42.0	42.03	42.07	42.11	42.15	42.19	42.23	42.27	42.31	42.35	42.40
.1	.13	.17	.22	.26	.30	.34	.38	.42	.46	.50
.2	.24	.28	.32	.36	.40	.44	.48	.52	.56	.60
.3	.32	.36	.41	.45	.49	.53	.57	.61	.65	.69
.4	.43	.47	.52	.56	.60	.64	.68	.72	.76	.80
42.5	42.54	42.58	42.62	42.66	42.70	42.74	42.79	42.83	42.87	42.91
.6	.65	.69	.73	.77	.81	.85	.89	.94	.98	43.02
.7	.73	.77	.82	.86	.90	.94	.98	43.02	43.06	.10
.8	.84	.88	.92	.97	43.01	43.05	43.09	.13	.17	.21
.9	.93	.97	43.01	43.05	.09	.13	.18	.22	.26	.30
43.0	43.03	43.07	43.12	43.16	43.20	43.24	43.28	43.33	43.37	43.41
.1	.14	.18	.23	.27	.31	.35	.39	.43	.48	.52
.2	.25	.29	.34	.38	.42	.46	.50	.54	.59	.63
.3	.34	.38	.42	.46	.51	.55	.59	.63	.67	.71
.4	.44	.49	.53	.57	.62	.66	.70	.74	.78	.82
43.5	43.53	43.57	43.62	43.66	43.70	43.74	43.79	43.83	43.87	43.91
.6	.64	.68	.73	.77	.81	.85	.89	.94	.98	44.02
.7	.75	.79	.84	.88	.92	.96	**44.00**	44.05	44.09	.13
.8	.83	.88	.92	.96	44.01	44.05	.09	.13	.18	.22
.9	.94	.99	44.03	44.07	.12	.16	.20	.24	.29	.33
44.0	44.03	44.07	44.12	44.16	44.20	44.25	44.29	44.33	44.38	44.42
.1	.14	.18	.23	.27	.31	.36	.40	.44	.49	.53
.2	.23	.27	.32	.36	.40	.44	.49	.53	.57	.62
.3	.34	.38	.43	.47	.51	.55	.60	.64	.69	.73
.4	.45	.49	.54	.58	.62	.67	.71	.75	.80	.84
44.5	44.53	44.58	44.62	44.67	44.71	44.75	44.80	44.84	44.88	44.93
.6	.64	.69	.75	.78	.82	.86	.91	.95	**45.00**	45.04
.7	.73	.77	.82	.86	.91	.95	**45.00**	45.04	.08	.13
.8	.84	.88	.93	.97	45.02	45.06	.11	.15	.20	.24
.9	.93	.97	45.02	45.06	.11	.15	.20	.24	.28	.33

Tables showing gravity of dry oil in oil-water mixtures, degrees A.P.I. with percent water in mixture less than one suggested by R. W. Miller, Phillips Petroleum Company, Oklahoma City, Oklahoma.

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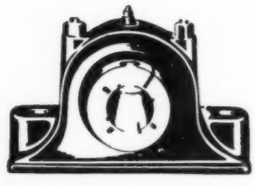

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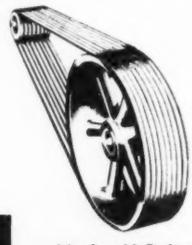

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GRAVITY OF DRY OIL IN OIL-WATER MIXTURES, DEG. A.P.I.

Gravity of "wet" oil deg. A.P.I.	Percent water in mixture														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
35.0	40.8	41.3	41.7	42.2	42.7	43.2	43.7	44.3	44.9	45.4	**46.0**	46.7	47.3	**48.0**	48.7
.1	.9	.4	.9	.4	.8	.4	.8	.4	45.1	.6	.1	.9	.5	.2	.8
.2	**41.0**	.5	**42.0**	.5	**43.0**	.5	**44.0**	.5	.2	.7	.3	**47.0**	.7	.4	**49.0**
.3	.2	.7	.1	.6	.1	.6	.1	.6	.3	.8	.5	.1	.8	.5	.2
.4	.3	.8	.2	.8	.2	.8	.2	.8	.4	.9	.6	.2	.9	.6	.4
35.5	41.4	41.9	42.4	42.9	43.4	43.9	44.4	**45.0**	45.6	46.2	46.8	47.4	48.1	48.8	49.5
.6	.5	**42.0**	.5	**43.0**	.5	**44.0**	.6	.1	.8	.3	**47.0**	.6	.3	**49.0**	.7
.7	.6	.1	.6	.1	.6	.1	.7	.3	.9	.4	.1	.7	.5	.2	.9
.8	.7	.2	.7	.2	.7	.2	.8	.4	**46.0**	.6	.2	.8	.6	.3	**50.0**
.9	.8	.3	.8	.3	.8	.3	.9	.5	.1	.7	.3	**48.0**	.7	.4	.1
36.0	42.1	42.6	**43.0**	43.6	44.1	44.6	45.1	45.7	46.3	46.9	47.6	48.2	48.9	49.6	50.3
.1	.2	.7	.1	.7	.2	.7	.3	.9	.5	**47.0**	.8	.4	**49.0**	.8	.5
.2	.3	.8	.2	.8	.3	.8	.4	**46.0**	.6	.2	.9	.6	.2	.9	.7
.3	.4	.9	.4	.9	.4	.9	.5	.1	.7	.3	**48.0**	.7	.4	**50.0**	.9
.4	.5	**43.0**	.5	**44.0**	.5	**45.0**	.6	.2	.8	.5	.1	.8	.5	.2	**51.0**
36.5	42.7	43.2	43.7	44.2	44.7	45.3	45.9	46.4	47.1	47.7	48.3	49.1	49.7	50.4	51.1
.6	.8	.3	.8	.3	.9	.4	**46.0**	.6	.2	.8	.5	.2	.9	.6	.3
.7	.9	.4	.9	.4	**45.0**	.5	.1	.8	.4	.9	.7	.4	**50.0**	.8	.5
.8	**43.0**	.5	**44.0**	.5	.1	.7	.2	.9	.5	**48.0**	.9	.5	.2	.9	.7
.9	.1	.6	.2	.6	.2	.8	.3	**47.0**	.6	.2	**49.0**	.6	.3	**51.0**	.9
37.0	43.3	43.8	44.4	44.9	45.4	**46.0**	46.6	47.2	47.8	48.4	49.1	49.8	50.5	51.2	52.1
.1	.4	.9	.5	**45.0**	.6	.2	.7	.4	.9	.5	.3	.9	.7	.4	.2
.2	.5	**44.0**	.6	.1	.7	.3	.9	.5	**48.0**	.7	.5	**50.0**	.9	.6	.4
.3	.6	.2	.7	.2	.8	.4	**47.0**	.6	.2	.9	.6	.2	**51.0**	.8	.6
.4	.7	.3	.8	.3	.9	.5	.1	.7	.3	**49.0**	.7	.4	.1	**52.0**	.7
37.5	**44.0**	44.5	45,1	45.6	46.1	46.7	47.3	47.9	48.5	49.2	49.9	50.6	51.3	52.1	52.8
.6	.1	.7	.2	.7	.2	.8	.4	**48.0**	.6	.4	**50.0**	.8	.5	.3	.9
.7	.2	.8	.3	.8	.3	.9	.5	.2	.8	.6	.2	.9	.7	.5	**53.0**
.8	.3	.9	.4	.9	.4	**47.0**	.6	.3	.9	.7	.3	**50.0**	.9	.6	.2
.9	.4	**45.0**	.5	**46.0**	.6	.2	.7	.4	**49.0**	.8	.5	.2	**52.0**	.7	.4
38.0	44.6	45.2	45.7	46.3	46.8	47.4	48.1	48.7	49.3	**50.0**	50.7	51.4	52.1	52.9	53.7
.1	.8	.3	.9	.4	.9	.6	.2	.9	.5	.2	.9	.6	.3	**53.0**	.9
.2	.9	.4	**46.0**	.5	**47.0**	.8	.4	**49.0**	.7	.4	**51.0**	.8	.5	.2	**54.0**
.3	**45.0**	.5	.1	.6	.2	.9	.5	.1	.8	.5	.2	.9	.7	.4	.2
.4	.1	.6	.2	.7	.3	**48.0**	.6	.2	.9	.6	.3	**52.0**	.8	.6	.4
38.5	45.3	45.8	46.4	46.9	47.5	48.1	48.7	49.4	**50.0**	50.7	51.4	52.2	52.9	53.7	54.5
.6	.4	.9	.5	**47.0**	.7	.2	.8	.5	.2	.8	.6	.4	**53.0**	.9	.6
.7	.5	**46.0**	.6	.2	.8	.4	.9	.6	.4	**51.0**	.8	.6	.2	**54.0**	.8
.8	.6	.2	.7	.3	.9	.5	**49.0**	.7	.5	.2	.9	.7	.4	.2	**55.0**
.9	.7	.3	.8	.4	**48.0**	.6	.2	.9	.6	.3	**52.0**	.8	.6	.4	.2
39.0	45.9	46.5	47.1	47.6	48.2	48.8	49.5	50.2	50.8	51.5	52.2	**53.0**	53.8	54.6	55.4
.1	**46.0**	.7	.2	.8	.4	.9	.7	.3	.9	.7	.4	.2	.9	.8	.5
.2	.2	.8	.4	.9	.5	**49.0**	.9	.5	**51.0**	.9	.6	.4	**54.0**	.9	.7
.3	.3	.9	.5	**48.0**	.6	.2	**50.0**	.6	.2	**52.0**	.8	.6	.2	**55.0**	.9
.4	.4	**47.0**	.6	.1	.7	.4	.1	.7	.4	.1	.9	.7	.4	.2	56.1
39.5	46.6	47.1	47.7	48.3	48.9	49.5	50.2	50.9	51.5	52.3	**53.0**	53.8	54.6	55.4	56.3
.6	.7	.2	.8	.5	**49.0**	.7	.4	**51.0**	.7	.5	.2	.9	.7	.6	.5
.7	.8	.4	.9	.6	.2	.8	.6	.2	.9	.7	.4	**54.0**	.9	.8	.7
.9	.9	.5	**48.0**	.7	.3	.9	.7	.3	**52.0**	.8	.6	.2	**55.0**	.9	.8
.9	**47.0**	.6	.1	.8	.4	**50.0**	.8	.4	.1	.9	.7	.4	.2	**56.0**	.9

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IN TEXAS

MAGNOLIA-AIRCO GAS PRODUCTS CO.

HOUSTON • BEAUMONT • WICHITA FALLS • FORT WORTH • DALLAS • EL PASO • SAN ANTONIO

AIRCO DISTRICT OFFICES IN PRINCIPAL CITIES

AIRCO — WILSON

Anything and Everything for GAS WELDING or CUTTING and ARC WELDING

Static Press.
900-995 lb.

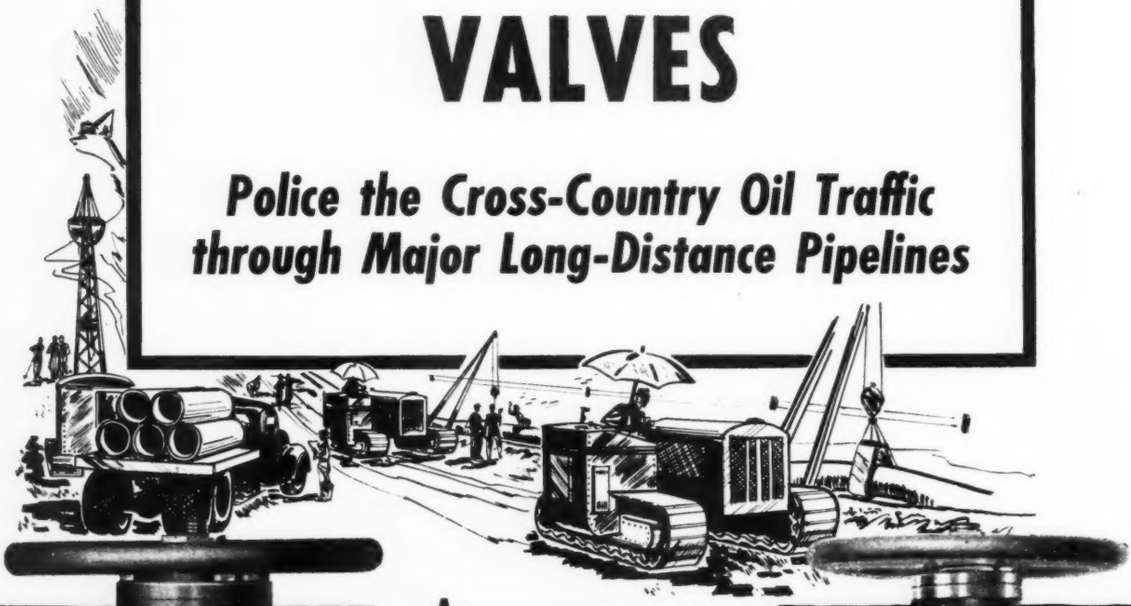
PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

Differential pressure, in. of water	Static pressure, lb. per sq. in. ga.																			
	900	905	910	915	920	925	930	935	940	945	950	955	960	965	970	975	980	985	990	995
2	42.77	42.89	43.00	43.13	43.24	43.35	43.47	43.58	43.69	43.81	43.92	44.03	44.15	44.26	44.37	44.48	44.60	44.71	44.82	44.94
4	60.50	60.66	60.82	61.00	61.16	61.32	61.48	61.64	61.80	61.96	62.12	62.28	62.44	62.60	62.76	62.92	63.08	63.24	63.40	63.56
6	74.08	74.28	74.47	74.69	74.89	75.09	75.28	75.48	75.67	75.87	76.07	76.26	76.46	76.65	76.85	77.05	77.24	77.44	77.63	77.83
8	85.55	85.77	86.00	86.25	86.48	86.71	86.93	87.16	87.39	87.61	87.84	88.06	88.29	88.52	88.74	88.97	89.20	89.42	89.65	89.87
10	95.65	95.90	96.16	96.44	96.69	96.95	97.20	97.45	97.71	97.96	98.21	98.46	98.72	98.97	99.22	99.48	99.73	99.98	100.2	100.5
12	104.8	105.1	105.3	105.7	105.9	106.2	106.5	106.8	107.0	107.3	107.6	107.9	108.1	108.4	108.7	109.0	109.3	109.5	109.8	110.1
14	113.2	113.5	113.8	114.1	114.4	114.7	115.0	115.3	115.6	115.9	116.2	116.5	116.8	117.1	117.4	117.7	118.0	118.3	118.6	118.9
16	121.0	121.3	121.6	122.0	122.3	122.6	123.0	123.3	123.6	123.9	124.2	124.6	124.9	125.2	125.5	125.8	126.2	126.5	126.8	127.1
18	128.4	128.7	129.0	129.4	129.8	130.1	130.4	130.8	131.1	131.4	131.8	132.1	132.5	132.8	133.1	133.5	133.8	134.2	134.5	134.8
20	135.3	135.6	136.0	136.4	136.8	137.1	137.5	137.8	138.2	138.5	138.9	139.3	139.6	140.0	140.3	140.7	141.0	141.4	141.8	142.1
21	138.6	139.0	139.4	139.8	140.1	140.5	140.9	141.2	141.6	142.0	142.3	142.7	143.1	143.4	143.8	144.2	144.5	144.9	145.3	145.6
22	141.9	142.2	142.6	143.0	143.4	143.8	144.2	144.5	144.9	145.3	145.7	146.0	146.4	146.8	147.2	147.5	147.9	148.3	148.7	149.0
23	145.1	145.5	145.8	146.3	146.7	147.0	147.4	147.8	148.2	148.6	149.0	149.3	149.7	150.1	150.5	150.9	151.3	151.6	152.0	152.4
24	148.2	148.6	149.0	149.4	149.8	150.2	150.6	151.0	151.4	151.8	152.2	152.6	152.9	153.3	153.7	154.1	154.5	154.9	155.3	155.7
25	151.3	151.7	152.1	152.5	152.9	153.3	153.7	154.1	154.5	154.9	155.3	155.7	156.1	156.5	156.9	157.3	157.7	158.1	158.5	158.9
26	154.2	154.7	155.1	155.5	155.9	156.3	156.7	157.2	157.6	158.0	158.4	158.8	159.2	159.6	160.0	160.4	160.8	161.2	161.6	162.0
27	157.1	157.6	158.0	158.5	158.9	159.3	159.7	160.1	160.6	161.0	161.4	161.8	162.2	162.6	163.1	163.5	163.9	164.3	164.7	165.1
28	160.1	160.5	160.9	161.4	161.8	162.3	162.7	163.1	163.5	163.9	164.4	164.8	165.2	165.6	166.1	166.5	166.9	167.3	167.8	168.2
29	162.9	163.3	163.8	164.2	164.7	165.1	165.5	166.0	166.4	166.8	167.3	167.7	168.1	168.6	169.0	169.4	169.8	170.3	170.7	171.1
30	165.7	166.1	166.6	167.0	167.5	167.9	168.4	168.8	169.2	169.7	170.1	170.6	171.0	171.4	171.9	172.3	172.7	173.2	173.6	174.1
31	168.4	168.9	169.3	169.8	170.3	170.7	171.2	171.6	172.1	172.5	172.9	173.4	173.8	174.3	174.7	175.2	175.6	176.1	176.5	177.0
32	171.1	171.6	172.0	172.5	173.0	173.4	173.9	174.3	174.8	175.3	175.7	176.2	176.6	177.1	177.5	178.0	178.4	178.9	179.3	179.8
33	173.8	174.2	174.7	175.2	175.7	176.1	176.6	177.1	177.5	178.0	178.4	178.9	179.4	179.8	180.3	180.7	181.2	181.7	182.1	182.6
34	176.4	176.9	177.3	177.8	178.3	178.8	179.2	179.7	180.2	180.6	181.1	181.6	182.0	182.5	183.0	183.4	183.9	184.4	184.8	185.3
35	179.0	179.4	179.9	180.4	180.9	181.4	181.9	182.3	182.8	183.3	183.8	184.2	184.7	185.2	185.6	186.1	186.6	187.1	187.5	188.0
36	181.5	182.0	182.5	183.0	183.5	184.0	184.4	184.9	185.4	185.9	186.4	186.8	187.3	187.8	188.3	188.8	189.2	189.7	190.2	190.7
37	184.0	184.5	185.0	186.0	186.0	186.5	187.0	187.5	188.0	188.5	189.0	189.4	189.9	190.4	190.9	191.4	191.9	192.3	192.8	193.3
38	186.5	187.0	187.4	188.0	188.5	189.0	189.5	190.0	190.5	191.0	191.5	191.9	192.4	192.9	193.4	193.9	194.4	194.9	195.4	195.9
39	188.9	189.4	189.9	190.5	191.0	191.5	192.0	192.5	193.0	193.5	194.0	194.5	195.0	195.5	196.0	196.5	197.0	197.5	198.0	198.5
40	191.3	191.8	192.3	192.9	193.4	193.9	194.4	194.9	195.4	195.9	196.5	197.0	197.5	198.0	198.5	199.0	199.5	200.0	200.5	201.0
41	193.7	194.2	194.7	195.3	195.8	196.3	196.8	197.3	197.9	198.4	198.9	199.4	200.0	200.4	200.9	201.4	202.0	202.5	203.0	203.5
42	196.1	196.6	197.1	197.7	198.2	198.7	199.2	199.7	200.3	200.8	201.3	201.8	202.3	202.9	203.4	203.9	204.4	204.9	205.4	206.0
43	198.3	198.9	199.4	200.0	200.5	201.0	201.6	202.1	202.6	203.1	203.7	204.2	204.7	205.2	205.8	206.3	206.8	207.3	207.9	208.4
44	200.6	201.2	201.7	202.3	202.8	203.4	203.9	204.4	205.0	205.5	206.0	206.6	207.1	207.6	208.1	208.7	209.2	209.7	210.3	210.8
45	202.9	203.5	204.0	204.6	205.1	205.7	206.2	206.7	207.3	207.8	208.4	208.9	209.4	210.0	210.5	211.0	211.6	212.1	212.6	213.2
46	205.2	205.7	206.2	206.9	207.4	207.9	208.5	209.0	209.6	210.1	210.6	211.2	211.7	212.3	212.8	213.4	213.9	214.4	215.0	215.5
47	207.4	207.9	208.5	209.1	209.7	210.2	210.8	211.3	211.9	212.4	212.9	213.5	214.0	214.6	215.1	215.7	216.2	216.8	217.3	217.9
48	209.6	210.1	210.7	211.3	211.9	212.4	213.0	213.5	214.1	214.6	215.2	215.7	216.3	216.8	217.4	218.0	218.5	219.1	219.6	220.2
49	211.8	212.3	212.9	213.5	214.1	214.6	215.2	215.7	216.3	216.9	217.4	218.0	218.5	219.1	219.7	220.2	220.8	221.3	221.9	222.5
50	213.9	214.4	215.0	215.7	216.2	216.8	217.4	217.9	218.5	219.1	219.6	220.2	220.8	221.3	221.9	222.5	223.0	223.6	224.2	224.7
51	216.0	216.6	217.2	217.8	218.4	218.9	219.5	220.1	220.7	221.2	221.8	222.4	222.9	223.5	224.1	224.7	225.2	225.8	226.4	226.9
52	218.1	218.7	219.3	219.9	220.5	221.1	221.7	222.2	222.8	223.4	224.0	224.6	225.1	225.7	226.3	226.9	227.4	228.0	228.6	229.2
53	220.2	220.8	221.4	222.0	222.6	223.2	223.8	224.4	225.0	225.5	226.1	226.7	227.3	227.9	228.3	229.0	229.6	230.2	230.8	231.4
54	222.3	222.9	223.5	224.1	224.7	225.3	225.9	226.5	227.1	227.6	228.2	228.8	229.4	230.0	230.6	231.2	231.8	232.3	232.9	233.5
55	224.3	224.9	225.5	226.2	226.8	227.4	228.0	228.6	229.2	229.7	230.3	230.9	231.5	232.1	232.7	233.3	233.9	234.5	235.1	235.7
56	226.4	227.0	227.6	228.2	228.8	229.4	230.0	230.6	231.2	231.8	232.4	233.0	233.6	234.2	234.8	235.4	236.0	236.6	237.2	237.8
57	228.4	229.0	229.6	230.3	230.9	231.5	232.1	232.7	233.3	233.9	234.5	235.1	235.7	236.3	236.9	237.5	238.1	238.7	239.3	240.0
58	230.4	231.0	231.6	232.3	232.9	233.5	234.1	234.7	235.3	235.9	236.6	237.2	237.8	238.4	239.0	239.6	240.2	240.8	241.4	242.0
59	232.4	233.0	233.6	234.3	234.9	235.5	236.1	236.7	237.3	238.0	238.6	239.2	239.8	240.4	241.0	241.6	242.3	242.9	243.5	244.1
60	234.3	234.9	235.6	236.3	236.9	237.5	238.1	238.7	239.4	240.0	240.6	241.2	241.8	242.4	243.1	243.7	244.3	244.9	245.5	246.2
61	236.3	236.9	237.5	238.2	238.8	239.5	240.1	240.7	241.3	242.0	242.6	243.2	243.8	244.5	245.1	245.7	246.3	247.0	247.6	248.2
62	238.2	238.8	239.4	240.2	240.8	241.4	242.0	242.7	243.3	243.9	244.6	245.2	246.8	246.5	247.1	247.7	248.3	249.0	249.6	250.2
63	240.1	240.7	241.4	242.1	242.7	243.3	244.0	244.6	245.3	245.9	246.5	247.2	247.8	248.4	249.1	249.7	250.3	251.0	251.6	252.2
64	242.0	242.6	243.3	244.0	244.6	245.3	245.9	246.6	247.2	247.8	248.5	249.1	249.8	250.4	251.0	251.7	252.3	253.0	253.6	254.2
65	243.9	244.5	245.2	245.9	246.5	247.2	247.8	248.5	249.1	249.8	250.4	251.1	251.7	252.3	253.0	253.6	254.3	254.9	255.6	256.2
66	245.8	246.4	247.1	247.8	248.4	249.1	249.7	250.4	251.0	251.7	252.3	253.0	253.6	254.3	254.9	255.6	256.2	256.9	257.5	258.2
67	247.6	248.3	248.9	249.6	250.3	251.0	251.6	252.3	252.9	253.6	254.2	254.9	255.5	256.2	256.8	257.5	258.2	258.8	259.5	260.1
68	249.4	250.1	250.8	251.5	252.2	252.8	253.5	254.1	254.8	255.5	256.1	256.8	257.4	258.1	258.8	259.4	260.1	260.7	261.4	262.1
69	251.3	252.0	252.6	253.4	254.0	254.7	255.4	256.0	256.7	257.4	258.0	258.7	259.3	260.0	260.7	261.3	262.0	262.7	263.3	264.0
70	253.1	253.8	254.4	255.2	255.9	256.5	257.2	257.9	258.5	259.2	259.9	260.5	261.2	261.9	262.6	263.2	263.9	264.6	265.2	265.9
71	254.9	255.6	256.2	257.0	257.7	258.3	259.0	259.7	260.4	261.0	261.7	262.4	263.1	263.7	264.4	265.1	265.8	266.4	267.1	267.8
72	256.7	257.4	258.0	258.8	259.5	260.2	260.8	261.5	262.2	262.9	263.5	264.2	264.9	265.6	266.3	266.9	267.6	268.3	269.0	269.7
73	258.5	259.1	259.8	260.6	261.3	262.0	262.6	263.3	264.0	264.7	265.4	266.1	266.7	267.4	268.1	268.8	269.5	270.2	270.8	271.5
74	260.2	260.9	261.6	262.4	263.0	263.7	264.4	265.1	265.8	266.5	267.2	267.9	268.6	269.2	270.0	270.6	271.3	272.0	272.7	273.4
75	262.0	262.7	263.4	264.1	264.8	265.5	266.2	266.9	267.6	268.3	269.0	269.7	270.4	271.0	271.8	272.4	273.1	273.8	274.5	275.2
76	263.7	264.4	265.1	265.9	266.6	267.3	268.0	268.7	269.4	270.1	270.8	271.5	272.2	272.9	273.6	274.3	275.0	275.7	276.4	277.1
77	265.4	266.1	266.8	267.6	268.3	269.0	269.7	270.4	271.1	271.8	272.6	273.3	274.0	274.7	275.4	276.1	276.8	277.5	278.2	279.0
78	267.2	267.9	268.6	269.4	270.2	270.8	271.5	272.2	272.9	273.6	274.3	275.0	275.7	276.4	277.1	277.9	278.6	279.3	280.0	280.7
79	268.9	269.6	270.3	271.1	271.8	272.5	273.2	273.9	274.6	275.4	276.1	276.8	277.5	278.2	278.9	279.6	280.3	281.0	281.7	282.5
80	270.6	271.3	272.0	272.8	273.5	274.2	274.9	275.7	276.4	277.1	277.8	278.5	279.2	279.9	280.7	281.4	282.1	282.8	283.5	284.2
82	273.9	274.6	275.4	276.2	276.9	277.6	278.4	279.1	279.8	280.5	281.2	282.0	282.7	283.4	284.1	284.9	285.6	286.3	287.0	287.8
84	277.2	278.0	278.7	279.5	280.3	281.0	281.7	282.5	283.2	283.9	284.7	285.4	286.1	286.9	287.6	288.3	289.1	289.8	290.5	291.3
86	280.5	281.3	282.0	282.9	283.6	284.3	285.1	285.8	286.6	287.3	288.1	288.8	289.5	290.3	291.0	291.8	292.5	293.2	294.0	294.7
88	283.8	284.5	285.3	286.1	286.9	287.6	288.4	289.1	289.9	290.6	291.4	292.1	292.9	293.6	294.4	295.1	295.9	296.6	297.4	298.1
90	287.0	287.7	288.5	289.4	290.1	290.9	291.6	292.4	293.1	293.9	294.7	295.4	296.2	296.9	297.7	298.5	299.2	300.0	300.7	301.5
92	290.2	290.9	291.7	292.6	293.3	294.1	294.9	295.6	296.4	297.2	297.9	298.7	299.5	300.2	301.0	301.8	302.5	303.3	304.1	304.8
94	293.3	294.0	294.8	295.7	296.5	297.2	298.0	298.8	299.6	300.4	301.1	301.9	302.7	303.5	304.2	305.0	305.8	306.6	307.3	308.1
96	296.4	297.2	298.0	298.8	299.6	300.4	301.2	302.0	302.8	303.5	304.3	305.1	305.9	306.7	307.5	308.2	309.0	309.8	310.3	310.4
98	299.4	300.2	301.0	301.9	302.7	303.5	304.3	305.1	305.9	306.7	307.5	308.3	309.0	309.8	310.6	311.4	312.2	313.0	313.8	314.6
100	302.5	303.3	304.1	305.0	305.8	306.6	307.4	308.2	309.0	309.8	310.6	311.4	312.2	313.0	313.8	314.6	315.4	316.2	317.0	317.8

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in., abs., and inches of water respectively.
Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.
Table has been condensed to serve field men in approximating meter readings; intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.

CHAPMAN VALVES

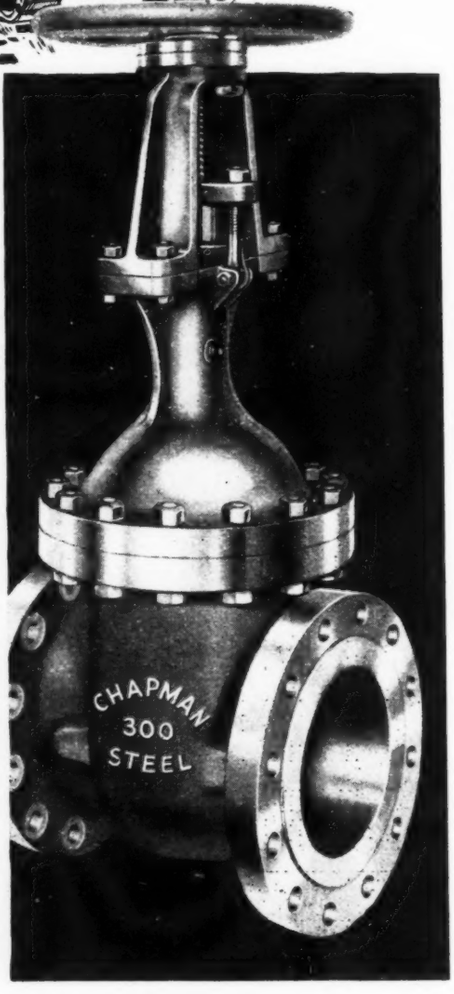
Police the Cross-Country Oil Traffic through Major Long-Distance Pipelines



A thorough working knowledge of actual operating conditions is plainly written into the specifications of every Chapman Valve for pipeline service. And these veteran valves speak for themselves, with unmarred performance records. So choose Chapman Pipeline Valves on *your* job for the same reasons that southwest oil-country men were chosen to go into the New England mountains to build the Portland-Montreal line . . . a background of thoroughgoing experience and know-how, plus the unlimited ability to "take it."

◀ Chapman Iron Body Gate Valve.

Chapman List 300 Solid Wedge Steel Gate Valve, for 300 lb. pressure at 750° F. ▶



THE CHAPMAN VALVE MANUFACTURING COMPANY
INDIAN ORCHARD, MASSACHUSETTS

VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH ANNULUS BETWEEN 2-IN. AND 4-IN. TUBING

Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	300	3.2	1.2	0.8	0.6	0.5	0.4	0.3	0.3	0.3
100		6.5	2.5	1.6	1.2	0.9	0.8	0.7	0.6	0.6
150		9.7	3.7	2.4	1.8	1.4	1.2	1.0	0.9	0.8
200		12.9	5.0	3.2	2.4	1.9	1.6	1.4	1.2	1.1
250		16.2	6.2	4.0	2.9	2.4	2.0	1.7	1.6	1.4
300		19.4	7.5	4.8	3.5	2.8	2.4	2.1	1.9	1.7
350		22.6	8.7	5.5	4.1	3.3	2.8	2.4	2.2	2.0
400		25.9	10.0	6.3	4.7	3.8	3.2	2.8	2.5	2.2
50	400	4.3	1.6	1.0	0.8	0.6	0.5	0.4	0.4	0.4
100		8.6	3.3	2.1	1.5	1.2	1.0	0.9	0.8	0.7
150		12.9	4.9	3.1	2.3	1.8	1.5	1.3	1.2	1.1
200		17.2	6.6	4.1	3.1	2.4	2.1	1.8	1.6	1.4
250		21.5	8.2	5.2	3.8	3.1	2.6	2.2	2.0	1.8
300		25.8	9.9	6.2	4.6	3.7	3.1	2.7	2.4	2.1
350		30.0	11.5	7.3	5.4	4.3	3.6	3.1	2.8	2.5
400		34.3	13.2	8.3	6.1	4.9	4.1	3.6	3.1	2.8
50	500	5.4	2.0	1.3	0.9	0.7	0.6	0.5	0.4	0.4
100		10.7	4.1	2.6	1.9	1.5	1.3	1.1	1.0	0.9
150		16.1	6.1	3.8	2.8	2.2	1.9	1.6	1.4	1.3
200		21.4	8.2	5.1	3.8	3.0	2.5	2.2	1.9	1.7
250		26.8	10.2	6.4	4.7	3.7	3.1	2.7	2.4	2.1
300		32.1	12.3	7.7	5.6	4.5	3.8	3.2	2.9	2.6
350		37.5	14.3	9.0	6.6	5.2	4.4	3.8	3.3	3.0
400		42.8	16.3	10.2	7.5	6.0	5.0	4.3	3.8	3.4
50	600	6.4	2.4	1.5	1.1	0.9	0.7	0.6	0.6	0.5
100		12.8	4.9	3.1	2.2	1.8	1.5	1.3	1.1	1.0
150		19.2	7.3	4.6	3.4	2.7	2.2	1.9	1.7	1.5
200		25.6	9.8	6.1	4.5	3.6	3.0	2.5	2.2	2.0
250		32.0	12.2	7.6	5.6	4.4	3.7	3.2	2.8	2.5
300		38.5	14.6	9.2	6.7	5.3	4.4	3.8	3.4	3.0
350		44.9	17.1	10.7	7.8	6.2	5.2	4.5	3.9	3.5
400		51.3	19.5	12.2	8.9	7.1	5.9	5.1	4.5	4.0
50	700	7.5	2.8	1.8	1.3	1.0	0.9	0.7	0.6	0.6
100		14.9	5.7	3.5	2.6	2.1	1.7	1.5	1.3	1.2
150		22.4	8.5	5.3	3.9	3.1	2.6	2.2	1.9	1.7
200		29.9	11.3	7.1	5.2	4.1	3.4	2.9	2.6	2.3
250		37.3	14.2	8.8	6.5	5.1	4.3	3.7	3.2	2.9
300		44.8	17.0	10.6	7.8	6.2	5.1	4.4	3.9	3.5
350		52.3	19.8	12.4	9.1	7.2	6.0	5.1	4.5	4.0
400		59.7	22.7	14.2	10.4	8.2	6.8	5.9	5.2	4.6
50	800	8.5	3.2	2.0	1.5	1.2	1.0	0.8	0.7	0.7
100		17.1	6.5	4.0	2.9	2.3	1.9	1.7	1.5	1.3
150		25.6	9.7	6.3	4.4	3.5	2.9	2.5	2.2	2.0
200		34.1	12.9	8.1	5.9	4.7	3.9	3.3	2.9	2.6
250		42.6	16.2	10.1	7.4	5.8	4.8	4.1	3.6	3.3
300		51.1	19.4	12.1	8.8	7.0	5.8	5.0	4.4	3.9
350		59.7	22.6	14.1	10.3	8.1	6.8	5.8	5.1	4.6
400		68.2	25.9	16.1	11.8	9.3	7.2	6.6	5.8	5.2
50	900	9.6	3.6	2.3	1.6	1.3	1.1	0.9	0.8	0.7
100		19.2	7.3	4.5	3.3	2.6	2.2	1.9	1.6	1.4
150		28.8	10.9	6.8	4.9	3.9	3.2	2.8	2.4	2.2
200		38.3	14.5	9.0	6.6	5.2	4.3	3.7	3.2	2.9
250		47.9	18.2	11.3	8.2	6.5	5.4	4.6	4.1	3.6
300		57.5	21.8	13.5	9.9	7.8	6.5	5.6	4.9	4.3
350		67.1	25.4	15.8	11.5	9.1	7.6	6.5	5.7	5.1
400		76.7	29.0	18.1	13.2	10.4	8.6	7.4	6.5	5.8

[1]Solution of gas and condensation under pressure are not considered; hence the values are maxima.
[2]Gas volumes entering into velocity calculations are based on tubinghead pressure; atmospheric pressure is assumed to be 15 lb. per sq. in. in calculating the number of atmospheres.

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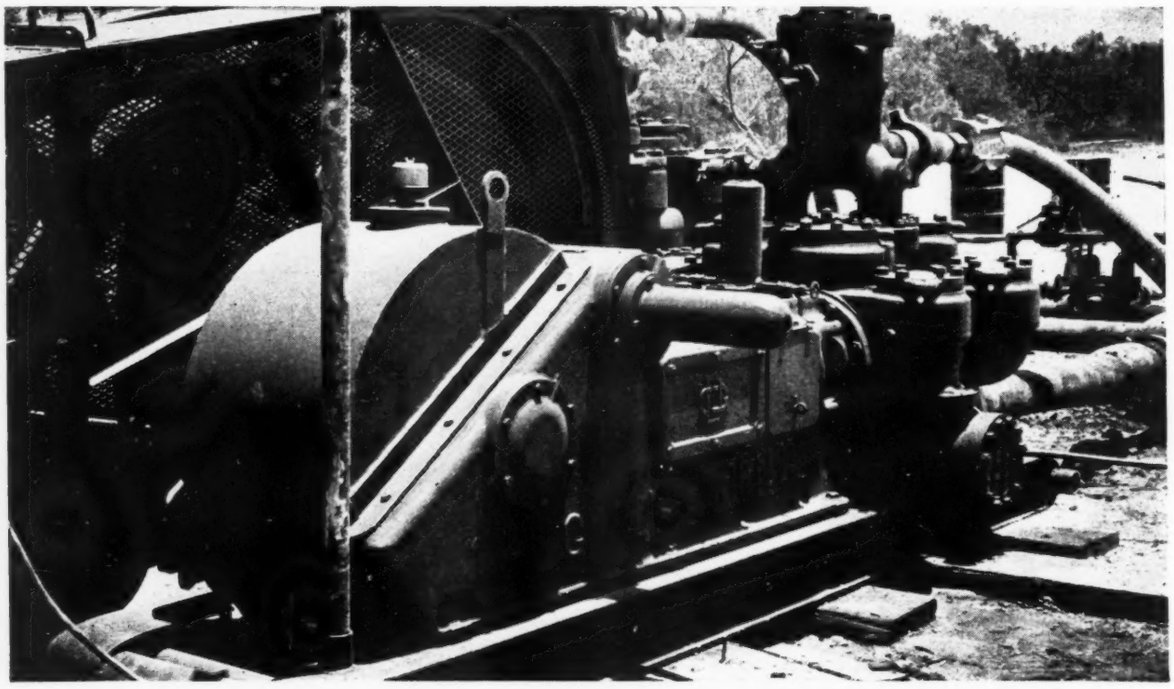

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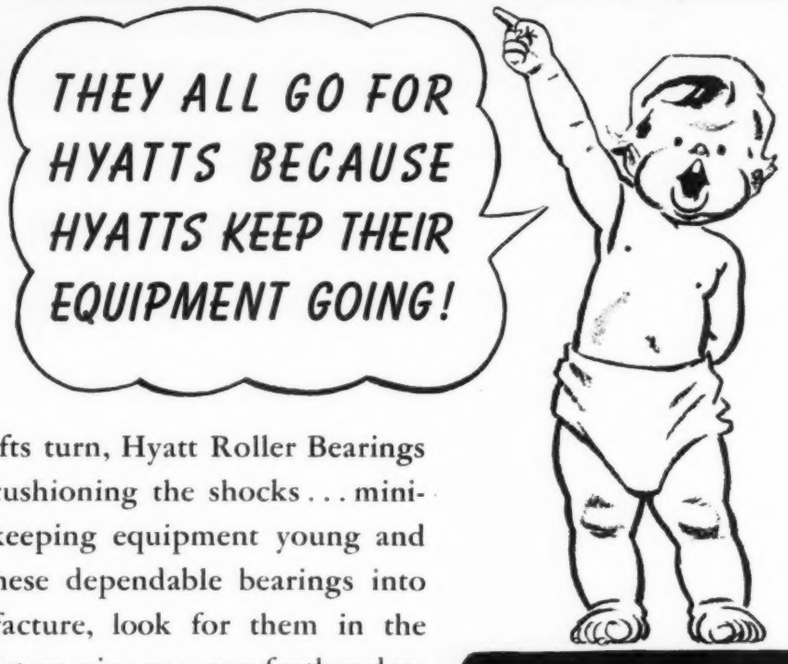

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QUIET

Electric Power Used to Drill World's Second Deepest Well

PETROLEUM ENGINEER Feature

☆ A total depth of 14,622 ft. of hole was drilled at an average daily cost of $47.59 for power and maintenance of equipment

by C. F. Forsberg

Electrical Superintendent, Honolulu Oil Corporation

as told to

WALLACE A. SAWDON

ALTHOUGH drilled with equipment not designed for drilling to the depths penetrated, Honolulu Oil Corporation experienced very little trouble in reaching 14,622 ft. in a well recently drilled with electric power at Buena Vista Hills near Taft, California. This well, designated as 25-P, is the deepest electrically-drilled well in the world and came within 382 ft. of reaching the record of the only other well that is deeper. No particular depth was contemplated when the well was begun June 1, 1940, as the objective was a thorough test of the oil and gas possibilities of the structure. The ultimate depth reached and the performance of the light equipment in drilling to such a depth is therefore of particular interest.

Experience in the effective use of electric motors for the drilling of oil wells played an important part in the success achieved. The Honolulu Oil Corporation has been drilling with electric power for many years and originally employed electrical equipment with cable tools in developing properties adjacent to Bakersfield. The company has used no other power for drilling during the last 10 years, because it has found that electric operation has been economical as well as adaptable to modern drilling practice. Approximately 125 wells have been drilled by Honolulu with electric power. The majority of these wells have been drilled by rotary and several have reached depths of 8000 ft.

As indicated by Fig. 1, which shows the hole sizes and casing program, this is not only the second deepest well yet drilled but is of large bore, the 10⅝-in. hole having been carried to below 12,000 ft. and 8½-in. hole to the final depth. A considerable amount of coring was done throughout the drilling of the well and core samples were taken wherever necessary to provide subsurface formation data. The hole was electrically logged to a depth of 12,821 ft.

C. F. FORSBERG

was graduated as an electrical engineer from Kansas State College in 1908 and after graduation worked for the municipal electric plant at Manhattan, Kansas, until 1910—He then went with General Electric Company and took that company's Test Course, working through the various shops and testing electrical equipment of all kinds—After spending some time in the GE plants at Pittsfield and Lynn, Massachusetts, he went to San Francisco for that company and remained until July, 1930—While in San Francisco Forsberg spent most of his time in the oil fields selling and installing equipment and doing engineering work—From 1930 to 1933 he was a manufacturer's agent in Los Angeles handling electrical equipment of all types—From April, 1933, to date he has been with the Honolulu Oil Corporation as the company's electrical superintendent.

The formations encountered between 3700 and 4500 ft. were troublesome and required much wall-scraping to keep the hole in condition. Key-seating occurred, after which large quantities of bit cuttings circulated from below began to accumulate in the oversize portions of the hole. It was for this reason that the hole was wall-scraped to 16-in. diameter from 3770 to 4451 ft.

The 11¾-in. casing was run and cemented at 3101 ft. after the hole had been drilled to 5600 ft. The 8⅝-in. casing was set at 5750 ft. after total depth had been reached. From 3101 ft. to 5760 ft. 11½-in. blades were run to scrape off the mud cake and from 5546 to 5750 ft. the hole was enlarged to 12¼-in. to provide a better encasement of cement around the shoe.

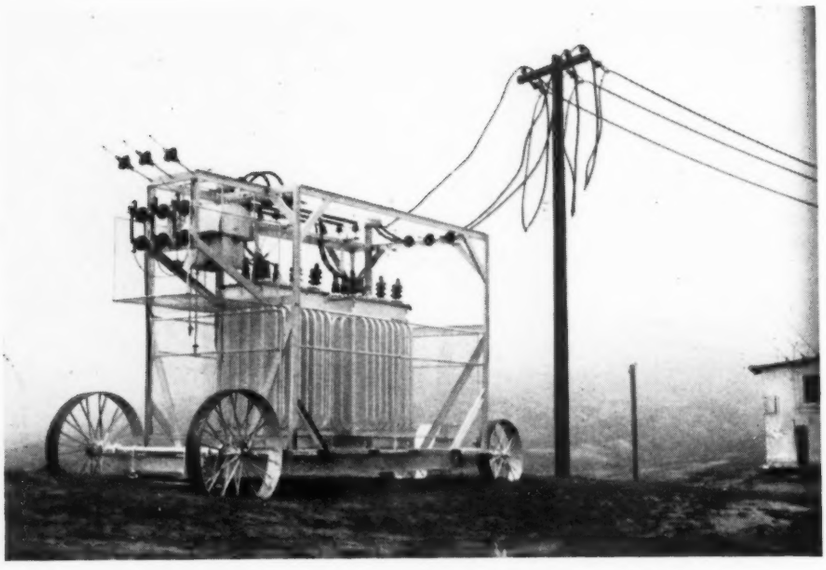
To 12,089 ft., 4½-in. full-hole drill pipe was used. At this point 1000 ft. of 4½-in. drill pipe was laid down and 1000 ft. of 3½-in. was used in the lower part of the drill string. Joints of 4½-in. were then progressively added to carry the well to 13,000 ft. and then more 3½-in. drill pipe was added. Although the rotary table speed could be increased to 231 r.p.m. at no load, the rotating speed was kept at a maximum of 150 r.p.m. during drilling.

The mud fluid was kept in condition at all times and was given the necessary weight to offset formation pressures by the addition of weight material. Reconditioning was done by chemical treatment and when additional colloidal qualities were desired prepared bentonite was added. The mud weight for the deeper drilling averaged approximately 103 lb. per cu. ft. and the viscosity was kept relatively high because of high solid content.

Considerable gas was encountered at various depths while drilling and frequent de-gasification of the mud fluid was thus advisable. A wooden flume set at an angle of 45 deg. and extending to 30 ft. above ground level was constructed for this purpose. The flume was made with baffles at suitable intervals and as the mud would flow over these barriers it would tend to break up and allow the gas to be released. The returns from the well first passed through one or both of two shaker screens so arranged that either or both screens could be put into service as desired. At this writing the hole has been plugged back to 11,056 ft. and testing of formations above this point is in progress.

Electrical Equipment

The rig was installed in a 136-ft. derrick and 1⅛-in. wire line was used



Power was delivered to the rig through this portable transformer bank

for the deeper hoisting. The drawworks was driven by two 8-pole, 440-volt, 125-hp. variable-speed motors direct-connected through flexible couplings to a twin motor reduction gear. The motors and reduction gear were mounted on one base as a unit and powered the drawworks through a chain drive from the reduction gear. The motors were operated with oil immersed magnetic controls through a small master switch so arranged that the two motors always operated on similar points of resistance and thus divided the load equally. Either one or both motors could be used for hoisting. This provided for uninterrupted operation in case trouble developed with one motor or its control, as a single motor run at lower rates of speed could usually be employed for hoisting. This feature was used to advantage several times during the drilling of the well.

The controls for the drawworks motors were installed in a portable house and permanently wired together. This equipment can be moved from one location to another after the drilling of a well is completed; when wiring a rig it necessitates only the running of the cables from the motors to the terminals at the portable control house and then making connections. This reduces wiring to a minimum and saves considerable time when rigging-up.

Individual rotary drive was used with a 440-volt, 8-pole, 125-hp. variable-speed motor direct-connected to the rotary machine by means of a flexible coupling. The motor and rotary machine were mounted as a single unit on a base fabricated of I-beams and 10-in. channel irons welded together, the derrick floor being notched to accommodate the unit. The motor was fully protected by covers to prevent any injury from objects on the derrick floor. A manually operated reversible controller with 9 points of speed control was installed for this motor in a small house back of the drawworks. The motor was connected to its control by means of flexible all-rubber cable and this arrangement also saved time in wiring.

Until a depth of approximately 14,000 ft. was reached the mud fluid was circulated by two power pumps: a 7¼-in. by 14-in. pump driven by a 125-hp., 8-pole variable-speed motor and a 7¼-in. by 16-in. pump driven by a 150-hp. motor of the same type. Both pumps were powered through V-belt drives from the motors, the top speeds being approximately 50 r.p.m. Manual control was employed and the controllers were set immediately back of the motors so as to be in the most accessible position. As with all manual controls used in drilling this well, proper motor protection was obtained by overload trips on oil circuit breakers as well as fused knife-entrance switches. The two pumps were operated in parallel most of the time and although they did not provide desired capacity for some time before they were replaced with a larger pump, they gave acceptable service as it was possible so to operate the controls that approximately equal loads could be held on the motors.

The two circulating pumps were finally replaced with a 7¾-in. by 20-in. power pump driven by two 125-hp. motors with the V-belt sheaves on the motors belted to one large sheave on the pump. This belting arrangement provided a pump speed of 50 r.p.m. When the large pump went into circulating service the two smaller pumps were held in reserve as standby units.

Mixing of the mud was at first done with a gas-engine-driven 5-in. by 12-in. power pump, the engine and pump being mounted on a wagon that thus formed a portable unit. Later a 6¾-in. by 14-in. pump driven by an 8-pole, 75-hp. variable-speed motor was installed to obtain the greater capacity that was more suitable to the job. Mud was circulated through the de-gassing flume with a 6¾-in. by 14-in. power pump driven through V-belts by a 25/65 hp. variable-speed motor, which picked the mud up from the tanks and raised it to the top of the flume, whence it was discharged to gravitate over the baffles. Operating the shaker screens through V-belt drives were 3-hp., 3-phase, 440-volt motors.

All motors and controls used

Fig. 1. Diagram of drilling and casing program

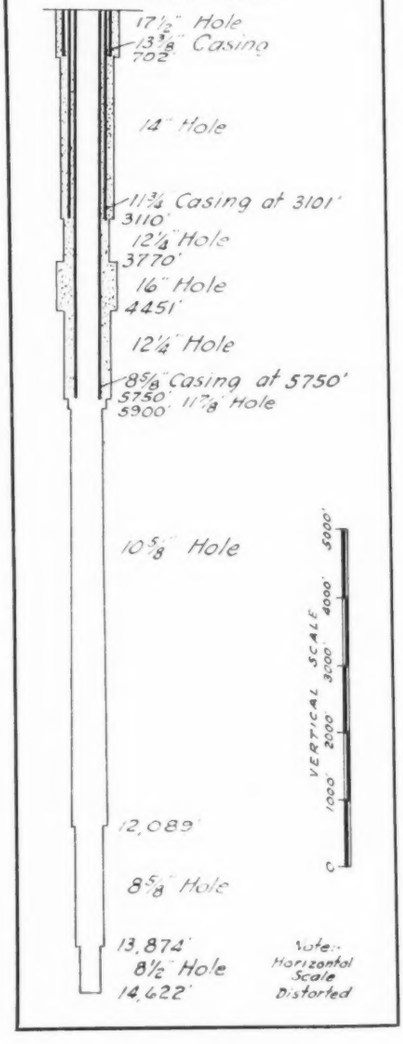


TABLE I

	Total	Per day
Labor maintenance costs, June 1, 1940 to July 1, 1941, including all servicing of equipment by electricians and all trouble jobs; also some overtime installation charges on rush jobs such as a pump installation, etc.	$ 2,436.55	$ 6.06
Maintenance cost of supplies, June 1, 1940, to July 1, 1941, including all electrical supplies and rewinding of one rotor on a 125-hp. motor	1,261.55	3.13
Power costs to June 12, 1941. This is 12½ months operation plus rigging-up time of 7 to 10 days	12,901.55	36.14
Water costs, June 1, 1940, to July 1, 1941	908.70	2.26
Total cost per day		$47.59

throughout the rig were of the explosion-proof type and the controllers were oil-immersed. Every precaution was thus taken to eliminate any hazard due to gas.

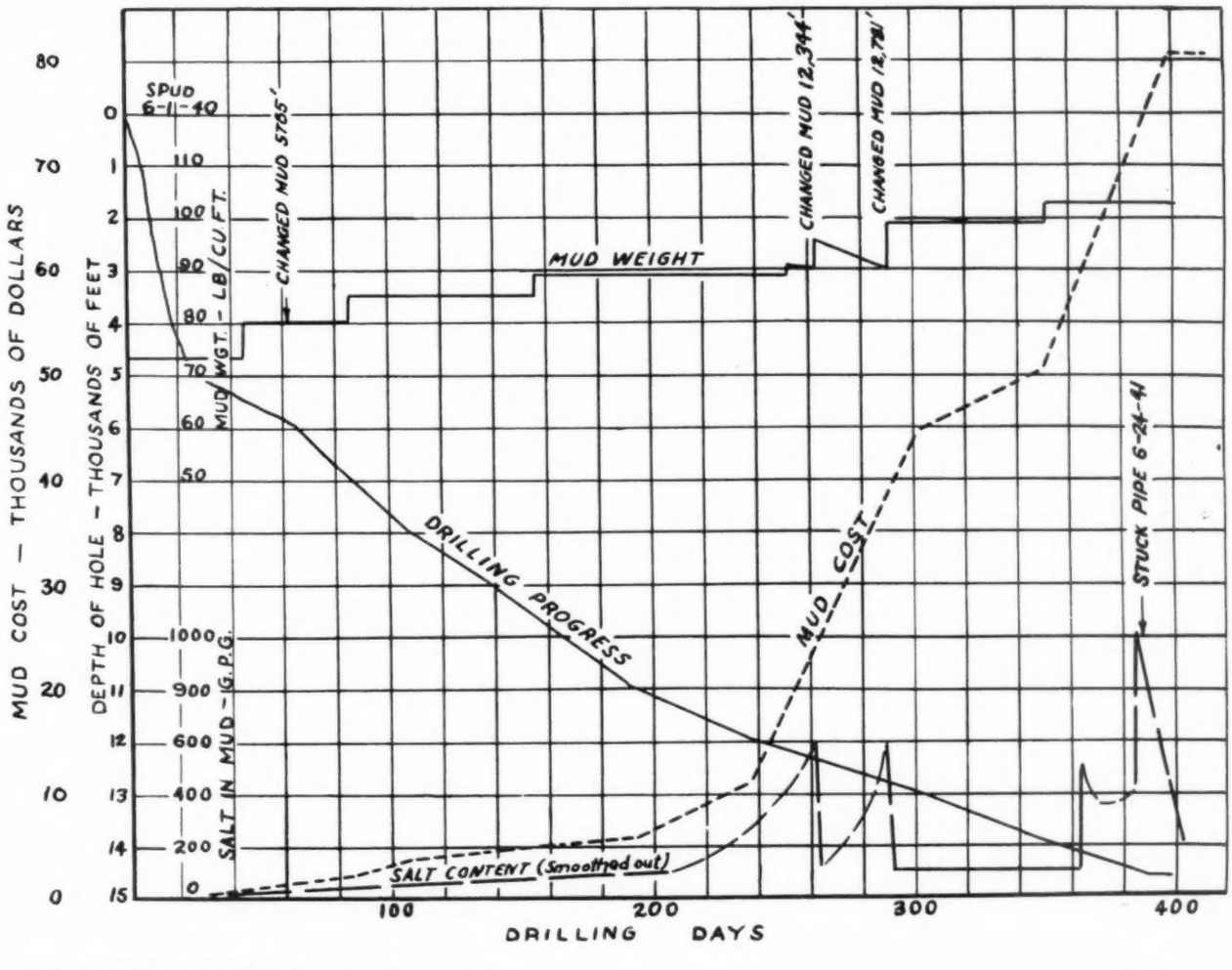
The purchased electric power supplying the company's operations is delivered at 66,000 volts to a substation owned and operated by the Honolulu Oil Corporation. Here it is stepped-down to 11,000-volt, 3-phase, 60-cycle current, which is distributed over the company's lines. The well is at a distance of about a mile from the substation and power for operation was transmitted through two 11,000-volt lines so that good voltage regulation could be maintained and full power obtained from the motors.

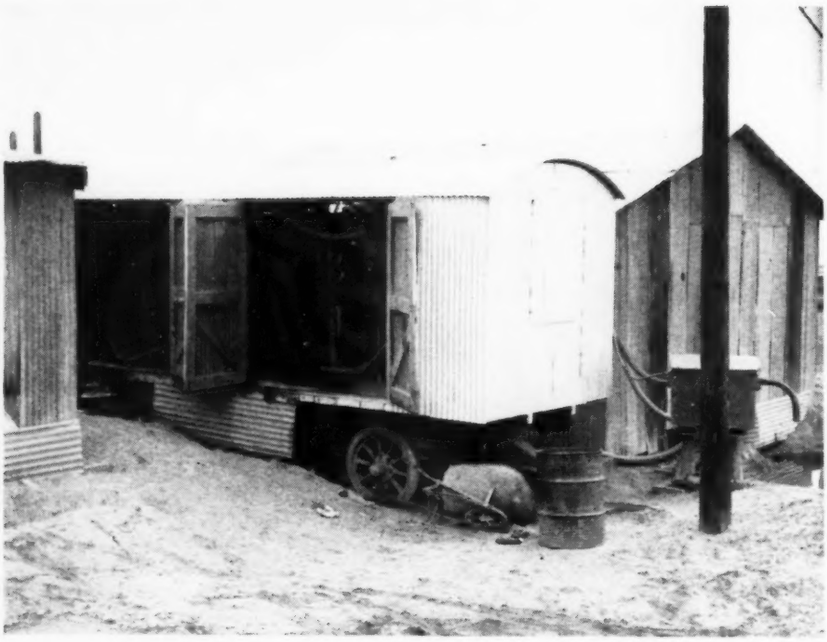
Power for the electrical equipment at the well was supplied by a portable transformer bank consisting of two 300-kva., 3-phase transformers connected in parallel and permanently wired together so that a minimum amount of work is necessary when making connections at a job. The transformers are set side by side with the primary and secondary sides wired through bus bars to make the job permanent. The entire equipment, including a metering cabinet housing meters for power measurements, is mounted on an underslung wagon bed as shown in an accompanying photograph.

The power was delivered to the primary side of the transformers at 11,000 volts and was stepped down to 460 volts. On the high side a set of disconnecting knife switches and a 3-pole oil circuit breaker complete with overload relays were used. Approximately 510 volts open circuit voltage was held on the low side.

Ammeters were installed in the rig to show the driller the load being pulled at all times during the drilling of the well. A red line was marked on each ammeter to indicate the danger line, the limit being set at 300 amp. for the drawworks motors and at 225 amp. for the motors driving the rotary machine and the mud pumps. Al-

Fig. 2. Chart of mud statistics on the Buena Vista Hills well
(Chart by courtesy J. H. McMasters, Honolulu Oil Corporation)





The controls for the drawworks motors were in this portable house, which was conveniently placed

though the drillers tried to observe these limits, the "danger lines" became the regular loads as greater depths were reached and in a great many cases the limits were exceeded. It was possible to control the load on the drawworks motors by merely shifting gears but it was found that control of loads on the table motor was not always possible as the power necessary merely to rotate in the heavy mud fluid being used required a current greater than 225 amp. By means of several tests made to determine the loads at different rotating speeds it was found that the greater part of the load on the table motor was utilized in merely turning the drill pipe as the load imposed by the bit was quite small. The current on the table motor would frequently run as high as 275 amp. and that on the pumps as high as 250 amp. Some control of power requirements was possible over the mud pump motors but not so much as was desired, for sufficient fluid to do the job had to be circulated. Remembering that 155 amp. is full-load current on the 125-hp. motors, the overload that the motors had to bear is appreciated.

Cost of Operation

The details of cost of operating the electrical equipment, including power, maintenance labor, supplies, and water, are given in Table 1. The power costs, including the 30-min. maximum demand as measured by graphic wattmeter and the kw-hr. consumption, are given in Table 2. It will be noted that the amount of power used after the first few months was quite uniform, the loads being about the same after steady values were reached. The increase in maximum demand was caused by the continuous operation of the two mud pumps in parallel after the fifth month and by the addition of the degasifier unit, which was installed when the well began penetrating formations that made it necessary. The maximum demand figures are for a 30-min. period although peak loads for short intervals ran considerably higher because the meter did not register such instantaneous values. The total power used from the beginning of actual drilling on June 1, 1940, to July 1, 1941, was 2,091,256 kw-hr. and the total quantity of water consumed during this period was 113,590 bbl., the cost of which is computed at $0.008 per bbl. (See Table 3.)

During a total of 9648 hours from June 1, 1940, to July 7, 1941, the time off due to failure of power or electrical equipment was only 44 hours, or one-half of one percent. More than half this failure, moreover, was occasioned by motor trouble that would not have occurred had the equipment been of proper capacity. One rotor "burn-out" on the table motor and the burning-out of wires in the shaft of the same motor were due entirely to overloading that could not be avoided. Although the performance of the electrical equipment could by no means be considered bad, it is believed that its record could have been improved considerably had the contingency of drilling at such unexpected depth not arisen and had larger equipment been in service.

Electrical Equipment for Deep Drilling

It now appears that, with equipment of proper size, electrical power can be used to drill deep wells such as this one with economy, with minimum trouble from the power end, and with results

TABLE 2
Details of power costs

Month 1940	*Kw-hr.*	*Max. demand for 30-min. period*	*Cost*
May 11 to June 12	45,024	288	$ 523.86
June 12 to July 11	83,040	336	783.70
July 11 to August 11	83,280	216	621.43
August 11 to September 11	104,280	312	834.77
September 11 to October 11	135,480	336	963.81
October 11 to November 12	177,192	468	1,292.50
November 12 to December 12	196,800	468	1,369.40
1941			
December 12 to January 11	191,760	480	1,349.85
January 11 to February 12	198,360	480	1,431.18
February 12 to March 12	159,600	432	1,166.45
March 12 to April 11	194,040	495	1,340.58
April 11 to May 12	168,720	437	1,224.02
May 12 to June 12	178,560	566	1,323.95
June 12 to July 1	85,560		

TABLE 3
Volume of water used and cost

Month 1940	*Barrels used*	*Cost at $0.008 per bbl.*
May	626	$ 5.01
June	13,320	106.56
July	9,213	73.70
August	5,568	44.54
September	4,649	37.19
October	10,546	84.37
November	8,586	68.69
December	9,669	77.35
1941		
January	8,573	68.58
February	10,033	80.26
March	11,483	91.86
April	9,720	77.76
May	11,604	92.83

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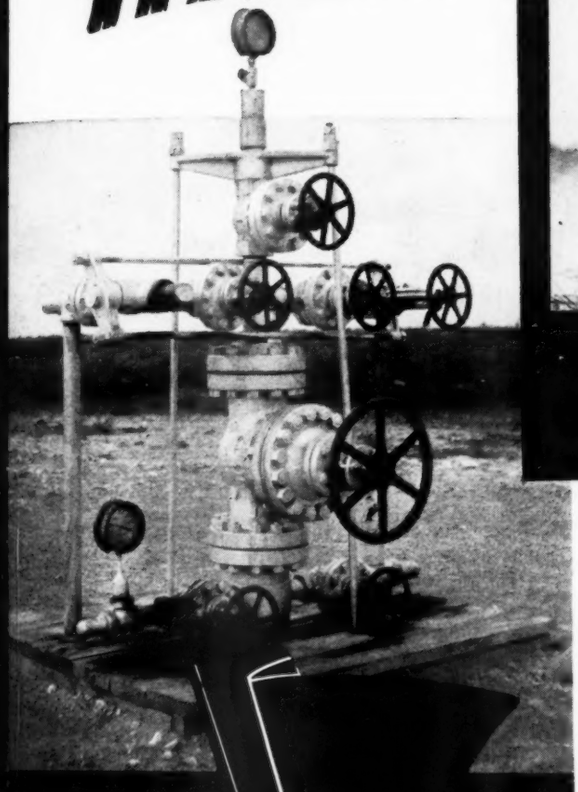

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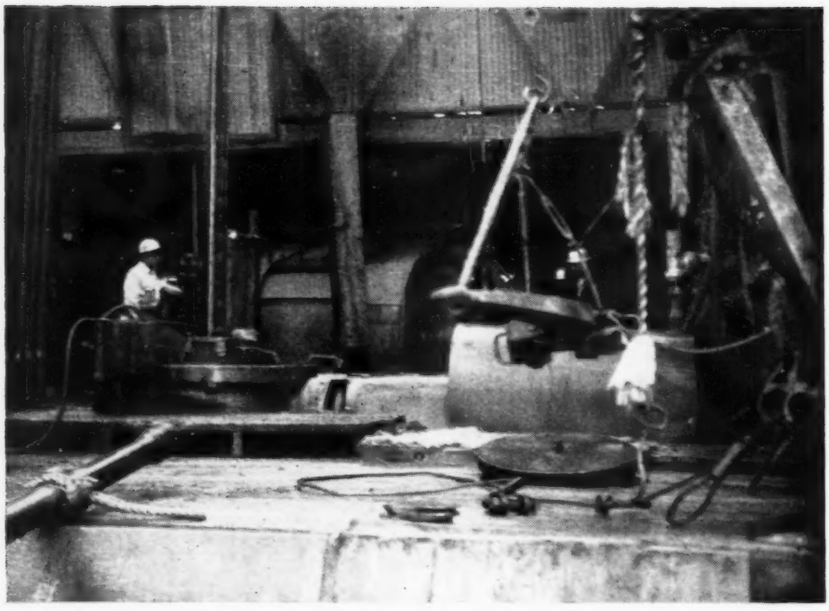


The motor driving the rotary table was completely enclosed to prevent damage during operations

as satisfactory as can be obtained with any other form of power. In evaluating performance on this well it must be borne in mind that the equipment employed was an accumulation that the company had gathered together over a period of years and was not designed for the job. Had the depth penetrated been contemplated the hole would not have been begun with such small equipment. More satisfactory operation of the motor driving the rotary machine would have been obtained had a speed reducer been placed between the motor and the table. This would have provided greater flexibility, for it was necessary to obtain all speed reductions by inserting resistance in the rotor circuit of the motor. The motor was therefore not operating economically at all times because this resistance would be in circuit merely to obtain the necessary speed reduction. A power cost reduction probably as great as $5.00 per day could have been made during many days when the motor was in continuous operation; moreover, more speeds would have been available, because the speed reducer in combination with the resistance would make for a more flexible unit.

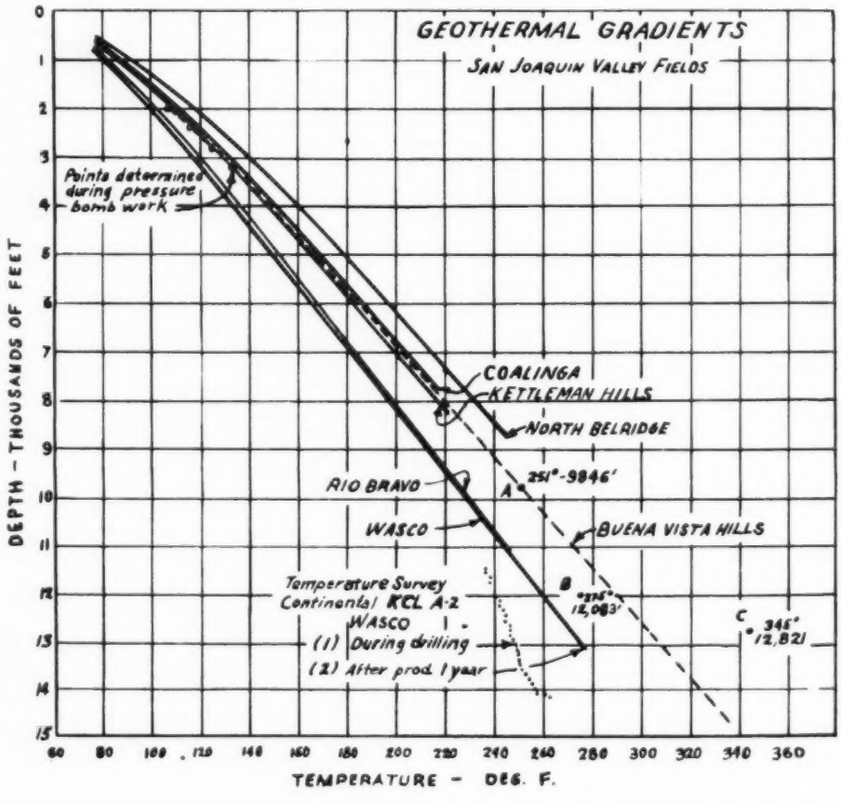
The operation of the two mud pumps was reasonably satisfactory but better performance could be obtained with modern control that permits stalling of the motors over an appreciable period of time. Better operation in paralleling the pumps would also have been possible with the new types of control now available.

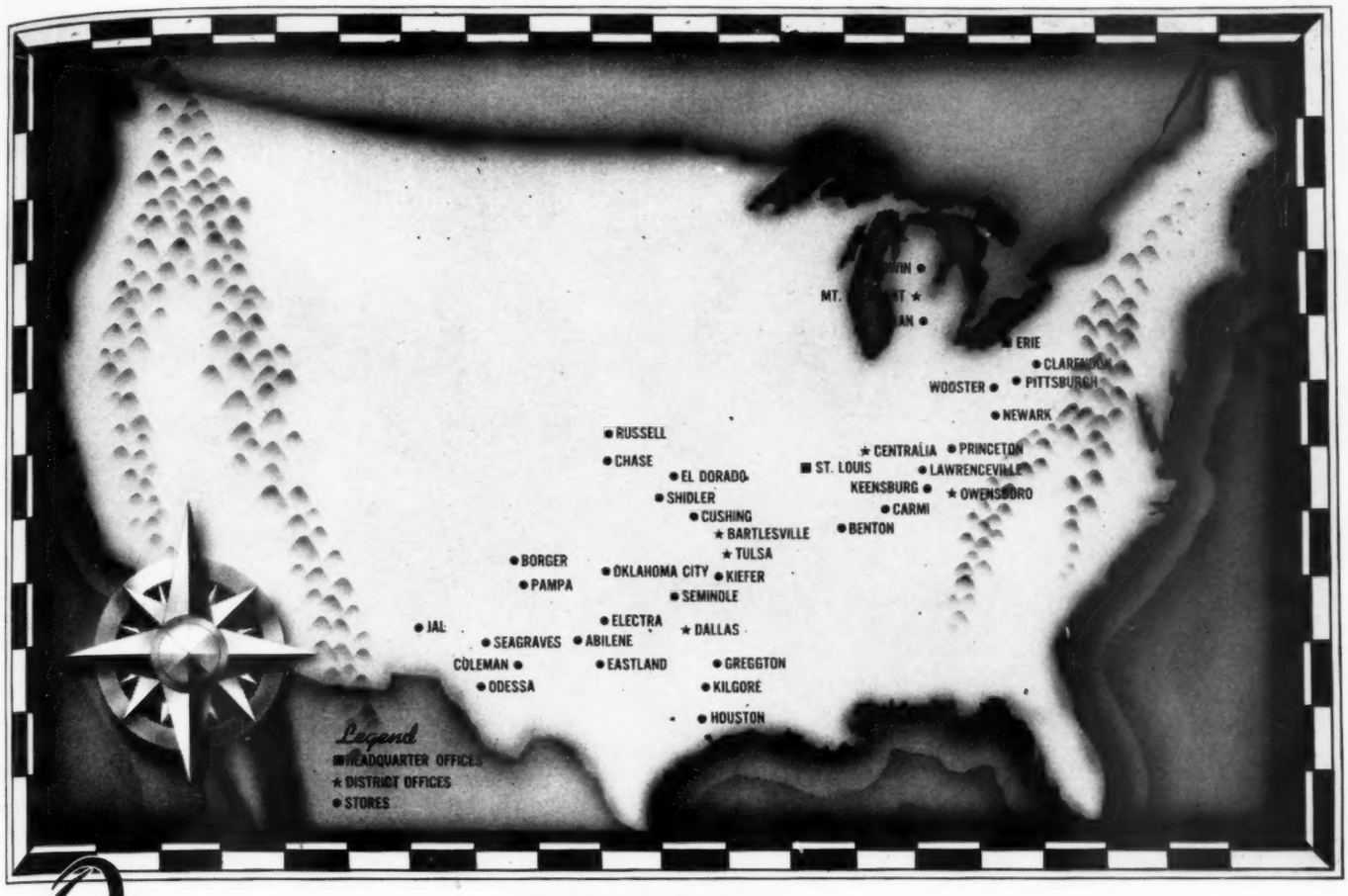
Modern deep-hole drilling demands speed and in order to meet this requirement it would seem that a 300-hp. motor on the rotary machine and two 300-hp. motors on the drawworks, with all necessary apparatus to go with them, would be desirable. Large mud pumps driven by motors of proper size would also be required and would eliminate the overloads that were necessary to drill this well. Features of the electric motor that must always be kept in mind are the high pull-out torque usually built into the motor and the capability of the motor to stand excessive overload for a time. These features are naturally dependent on the design but the usual type of variable-speed motor selected for this work has a pull-out torque of approximately 400 percent, which means it can do a very considerable job in a pinch.

The Honolulu Oil Corporation has endeavored to keep the same size and make of motor on all its rigs so that, in emergencies, the equipment can be interchanged to good advantage. A minimum of spare parts is thus required, and, by having one motor in reserve, very little time has been lost by the corporation during its many years of drilling with electric power.

Fig. 3. Temperature gradient of Honolulu's Buena Vista Hills well compared with gradients of other San Joaquin wells

(Chart by courtesy J. H. McMasters, Honolulu Oil Corporation)





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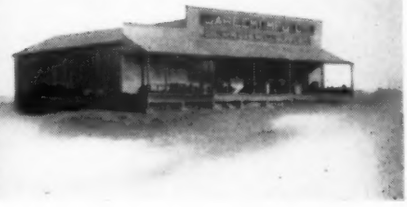

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A Review of the Fundamentals of Hydraulics

☆ Use of weirs in gasoline plants and refineries to measure fluid flow makes it important for the plant operator to understand a few basic principles of hydraulics

by Roy W. Machen

Superintendent, Hamman Exploration Company

THAT branch of physics dealing with the laws that govern liquids in motion is known as hydraulics, the term "hydraulics" being derived from the Greek and meaning that which "pertains to water." The application of these laws of liquids in motion in a practical manner to the continued well being and growth of mankind into a progressive betterment of living conditions has given rise to the science known as "hydraulic engineering."

Hydraulics is not an exact science, but rather an engineering science that has grown almost entirely because of experimental determinations resulting from continued investigation. The investigation and the interpretation of results, obviously, have been based on a scientific theoretical background.

The application of the principles of hydraulics to any problem is basically one depending on precise judgment and sound experience. The results obtained from the many formulas used in the attainment of the solution to any problem in hydraulics will depend on the judicious selection of the proper factors and coefficients to be inserted.

Fundamental Facts

In the study of hydraulics, two types of formulas are devised. One type is deduced from the assumption that the liquid is perfect. This type of formula is known as a "rational formula."

When it is desired to use a formula that will apply to imperfect liquids, taking into consideration the conditions of actual flow, the rational formula is modified by the insertion of certain factors or coefficients that have been obtained through experiment and are known to reflect correctly the effects due to certain conditions that are known to exist and that in so existing will modify the results obtained by using the "rational formula." This type of formula is known as an "empirical formula," and the numbers inserted to reflect the conditions of flow are known as "empirical constants."

ROY W. MACHEN

received a bachelor's degree from Oklahoma City University in 1927—Employed for six and one-half years by the Peppers Gasoline Company as refinery clerk, refinery and gasoline plant chemist, and gas engineer—Later saw service with various independent refining companies as gas engineer, operator in high-pressure gasoline plants, refinery construction engineer, and superintendent of refinery operations—Now is superintendent for the Hamman Exploration Company—Is a registered petroleum and natural gas engineer.

A mass of liquid possesses energy due either to position, motion, or the pressure to which it is subjected. That potential energy due to position is known as "energy of position;" that energy due to motion is termed kinetic energy, and that certain energy potentially present due to the pressure exerted on the liquid is known as "pressure energy."

The same laws that apply to falling bodies also hold true theoretically for water, when descending or flowing from one level to another. A jet of water released from an orifice at some point below the surface of the water contained by any reservoir will issue from that orifice with the same velocity as would have been attained by an object falling through an equal distance as that from the surface of the water in the reservoir to the center of the orifice. The velocity of flow is directly dependent on the height of the liquid above the orifice.

Theoretically, if the orifice from which water issues is turned upward, the jet will rise as high as the level of the water in the reservoir. The friction caused by air resistance and that of the liquid as it issues through the orifice, however, is such that the water never reaches that elevation.

Hydrostatic or "Static Head"

The term $\frac{v^2}{2g}$ may be taken to represent the height that a body must fall from rest in order to attain the velocity v. This height is termed the velocity head. The term, $\frac{p}{w}$, is known as the pressure head and represents the head necessary to produce the pressure p in lb. per sq. in.

If the quantity of water flowing through a pipe or channel is maintained constant and frictional resistance is neglected, the sum of the velocity head, pressure head, and potential head will be the same at all sections. Inasmuch as the pressure head and velocity head at the surface of the reservoir are each equal to 0, the sum of the three heads is h, the height of the reservoir surface above the plane of datum; hence, the sum of the three heads at any section is equal to h, or the hydrostatic head, more commonly known as the "static head."

The volume or quantity of water discharged is usually denoted in the formula by the symbol, "Q." If the water passes a given point continuously with the same velocity, the quantity passing in 1 second would be equal to the volume of a prism whose length is v and whose base is A, the area of the cross-section of the point selected for reference.

$$Q = Av \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The expression "velocities at any

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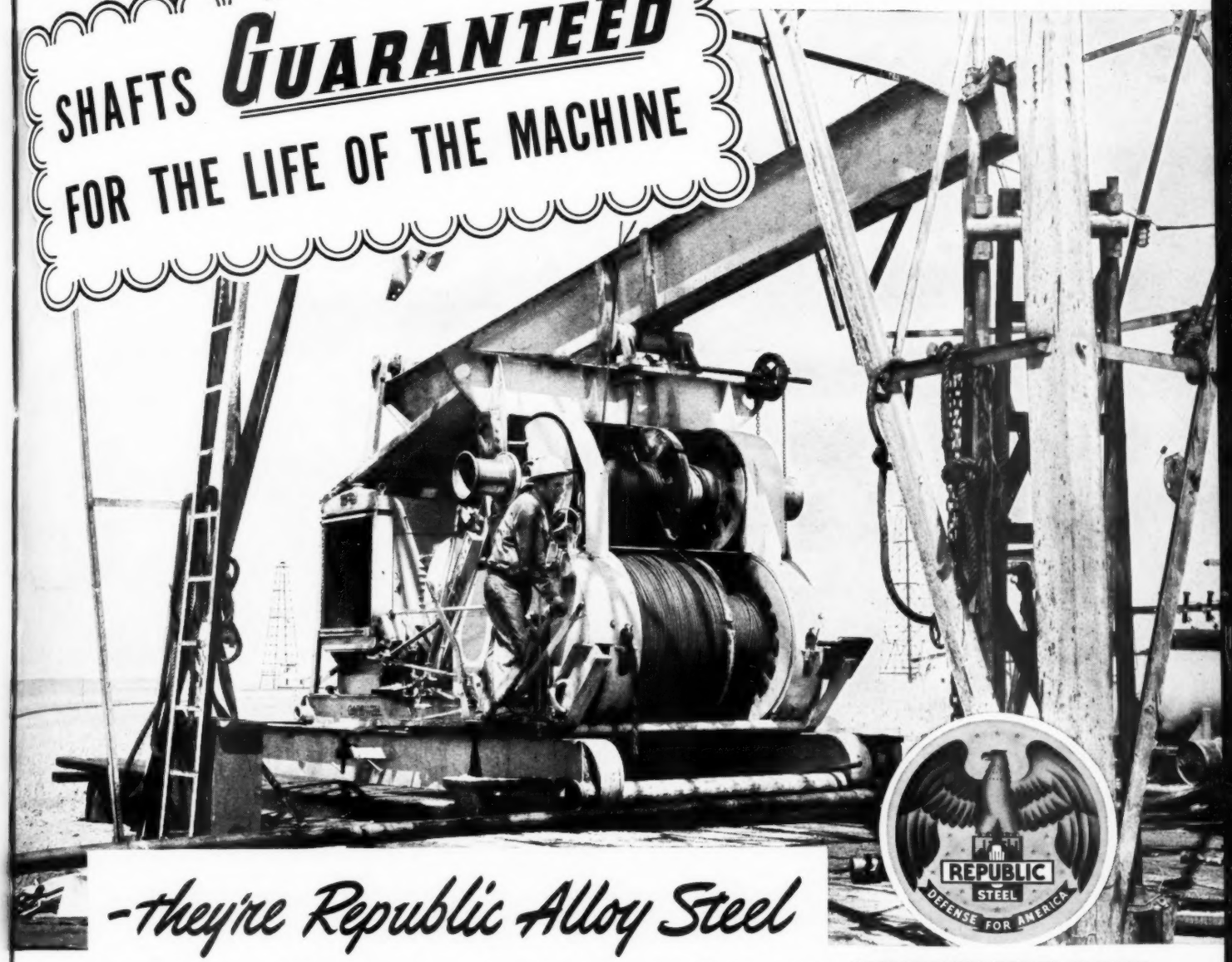

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two cross-sections are inversely proportional to the areas of those cross-sections" is a fundamental principle. In other words, if two cross-sections have the areas A_1 and A_2 and a velocity of v_1 exists at cross-section A_1 and a velocity v_2 exists at cross-section A_2, the formulated expression of the above-stated principle would be $\frac{v_1}{v_2} = \frac{A_2}{A_1}$. At cross-section A_1, $Q = A_1 v_1$ and at cross-section A_2, $Q = A_2 v_2$. As the quantity of water passing through the two cross-sections must be constant and only the cross-section has varied, the velocity has necessarily had to decrease or increase with the decrease or increase in cross-sectional area, and $A_1 v_1 = A_2 v_2$.

Example: Given a static head of 8 ft. and a cross-sectional area of 12.5664 sq. in. at the point of reference, what is the velocity and quantity of water passing the point of reference expressed in gal. per min. if the flow is uniform and frictionless?

Because: $h = \frac{v_2}{2g}$ . . . . . (2)

$V = \sqrt{2gh}$ . . . . . (3)

Using 32.16 for g, and 8.02 for $\sqrt{2g}$, formula 3 becomes:

$v = 8.02\sqrt{h}$ . . . . . (4)

and,

$h = \frac{v^2}{2g} = \frac{v^2}{2 \times 32.16} = .01555\ v^2$ . . . . . (5)

Solution: $v = 8.02\sqrt{8} = 8.02 \times 2.8284 = 22.68$ or 22.7 ft. per sec.

$Q = 22.7 \times \frac{12.5664}{144} = 1.98$ cu. ft. per sec.

$1.98 \times 60 \times 7.4805 = 888.68$ or 889 gal. per min.

If the volume of water passing through a pipe is known, the volume at any section being equal to the area of that section times the velocity, the velocity at any section is therefore equal to the volume divided by the area.

Example 2: The hydrostatic head is 10 ft. and the pressure head as determined by the use of a piezometer (a gauge or tube that is inserted in a pipe to show the actual pressure of the water) is 7 ft., what is the velocity at the section?

Solution: Let h = hydrostatic head and P = pressure head:

$h - P =$ velocity head $= \frac{v^2}{2g}$

$\frac{v^2}{2g} = 10 - 7 = 3$ ft.

therefore,

$v^2 = 2g \times 3$ or $v = \sqrt{2g \times 3} = \sqrt{2 \times 32.16 \times 3} = 13.89$ or 13.9 ft. per sec.

Flow of Water Through Orifices

An orifice is an opening through which water may flow for the purpose of measurement. It may be one of several shapes, the shape of the orifice being a definite factor in the methods of measurement used.

If the orifice is small compared with the distance that it is below the surface of the water in the reservoir, its dimension may be neglected with little effect on the results, and the head on the orifice may be taken as the distance of any part of it from the surface. It is usually assumed, however, that the head, h, is taken as that distance from the surface to the center of the orifice. If the water is assumed to discharge freely into the atmosphere with the velocity v, the potential and pressure heads are both equal to zero and the velocity head is equal to the static head, $h = \frac{v^2}{2h}$, or $v = \sqrt{2gh}$. The value v is termed the theoretical velocity. Due to friction and other resistances, however, the theoretical velocity is a little greater than the actual velocity and it is necessary to insert a coefficient of velocity into the formula. The coefficient of velocity is greater for high heads than for low, but it has been found by experimentation that the values range from 0.975 to nearly 1. The average value of 0.98 is ordinarily used and the formula takes the form: $v = C\sqrt{2gh}$.

The actual discharge through an orifice is less than the theoretical discharge because of the contraction of the jet at the point of emergence, and also, as was discussed in the preceding paragraph, because of the reduction of the theoretical velocity. The ratio of the actual discharge to the theoretical is termed the coefficient of discharge. The coefficient of discharge is then equal to the product of the coefficient of velocity and the coefficient of contraction. For close approximate calculations, it is permissible to use the value 0.62 for the coefficient of contraction and 0.98 for the coefficient of velocity. The coefficient of discharge is then: $C_d = c_v \times c_c = 0.62 \times 0.98 = 0.61$.

The formulas for actual discharge would then take the forms as follows: If the head is at least four times the vertical dimension of the orifice:

$Q = 8.02 C_d A\sqrt{h}$ . . . . . (6)

If the orifice is circular and of diameter d in ft., $A = 0.7854\ d^2$, and

$Q = 8.02 \times 0.7854\ C_d\ d^2\sqrt{h}$ . . (7)

If the orifice is a square with a side dimension of d ft., $A = d^2$ and $Q = 8.02\ C_d\ d^2\sqrt{h}$ . . . . . (8)

If the orifice is rectangular with the width b and the depth d, $A = bd$, and

$Q = 8.02\ C_d\ bd\sqrt{h}$ . . . . (9)

Example: Find the actual discharge from a circular orifice 4 in. in diameter with a head of 20 ft.

Solution: The area of the orifice,

$A = 0.7854\ d^2 = \frac{0.7854 \times 4^2}{144} = 0.0873$ sq. ft.

$Q = 8.02 \times 0.61 \times \sqrt{h} = 8.02 \times 0.61 \times \sqrt{20} = 21.9$ cu. ft. per sec.

The preceding formulas apply only to orifices from which the flow of water is to the atmosphere. Many times it is required to obtain the discharge through an orifice that is submerged. This situation may be met by using the following formula: $Q = 8.02\ A\sqrt{h_o}$, where Q is the quantity of discharge, A is the area of the orifice, and h_o is equal to the difference between the head h_1 on the upstream side of the orifice and h_2, the head on the downstream side of the orifice.

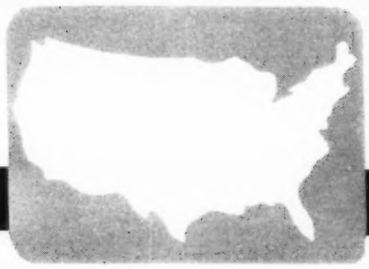
In many cases it is desired to measure water in terms of the "miner's inch." This method of measurement is used quite commonly in the irrigation and mining sections. The miner's inch is that quantity of water that flows during a certain period of time through an orifice of specified dimension and under a certain specified head. The dimensions of the orifice and the fixed

TABLE I

Coefficient of discharge for weirs with end contractions

Effective head, ft.	Length of weir in feet						
	0.66	1	2	3	5	10	19
0.1	0.632	0.639	0.646	0.652	0.653	0.655	0.656
0.15	0.619	0.625	0.634	0.638	0.640	0.641	0.642
0.20	0.611	0.618	0.626	0.630	0.631	0.633	0.634
0.25	0.605	0.612	0.621	0.624	0.626	0.628	0.629
0.30	0.601	0.608	0.616	0.619	0.621	0.624	0.625
0.40	0.595	0.601	0.609	0.613	0.615	0.618	0.620
0.50	0.590	0.596	0.605	0.608	0.611	0.615	0.617
0.60	0.587	0.595	0.601	0.605	0.608	0.613	0.615
0.70		0.590	0.598	0.603	0.606	0.612	0.614
0.80			0.595	0.600	0.604	0.611	0.613
0.90			0.592	0.598	0.603	0.609	0.612
1.00			0.590	0.595	0.601	0.608	0.611
1.20			0.585	0.591	0.597	0.605	0.610
1.40			0.580	0.587	0.594	0.602	0.609
1.60			....	0.582	0.591	0.600	0.607

Note: The head given is the effective head, H+1.33h. When the velocity of approach is small, h is neglected.



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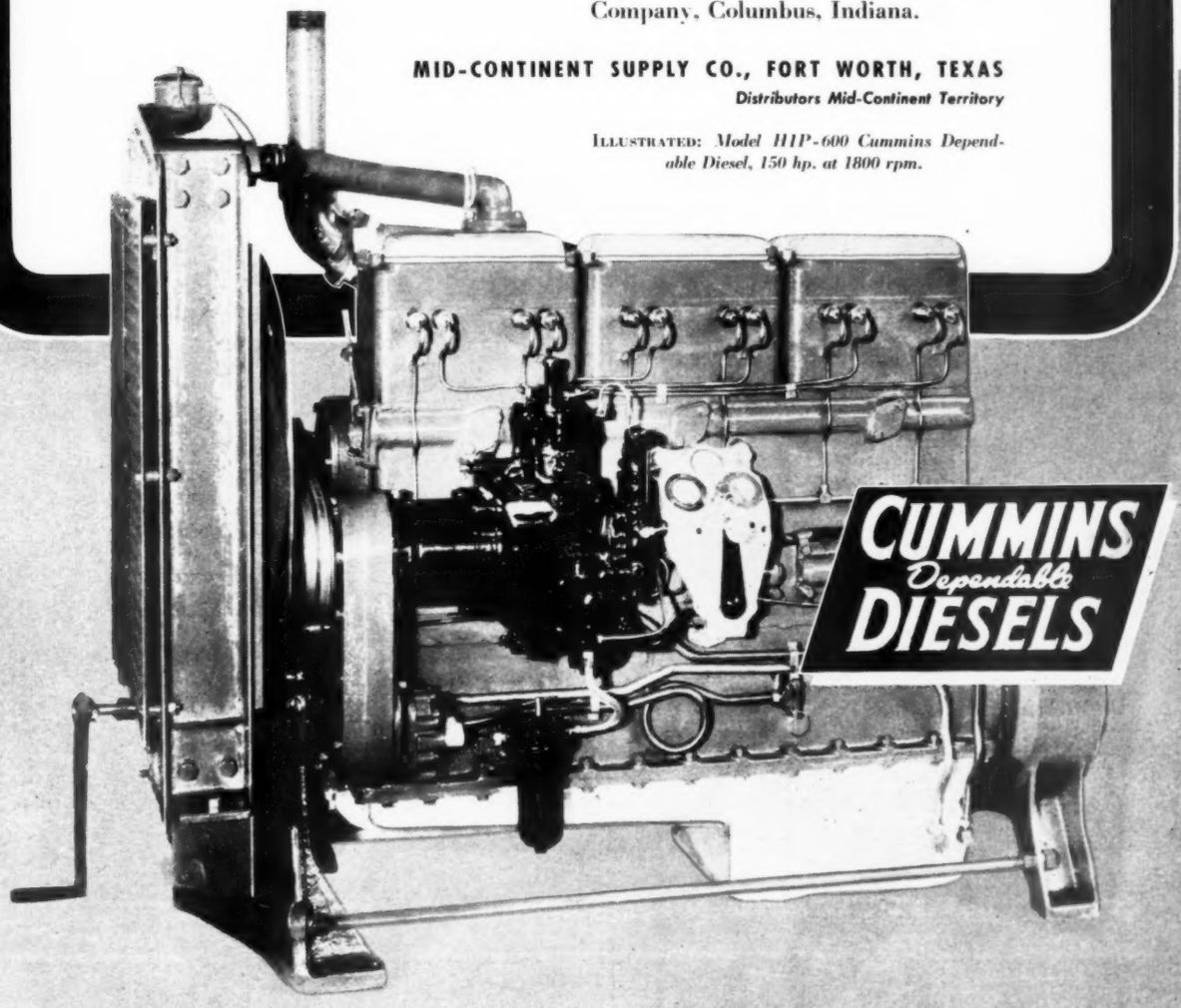

TABLE 2

Coefficient of discharge for weirs without end contractions

Effective head, ft.	Length of weir in feet						
	19	10	7	5	4	3	2
0.10	0.657	0.658	0.659				
0.15	0.643	0.644	0.645	0.645	0.647	0.649	0.652
0.20	0.635	0.637	0.637	0.638	0.641	0.642	0.645
0.25	0.630	0.632	0.633	0.634	0.636	0.638	0.641
0.30	0.626	0.628	0.629	0.631	0.633	0.636	0.639
0.40	0.621	0.623	0.625	0.628	0.630	0.633	0.636
0.50	0.619	0.621	0.624	0.627	0.630	0.633	0.637
0.60	0.618	0.620	0.623	0.627	0.630	0.634	0.638
0.70	0.618	0.620	0.624	0.628	0.631	0.635	0.640
0.80	0.618	0.621	0.625	0.629	0.633	0.637	0.643
0.90	0.619	0.622	0.627	0.631	0.635	0.639	0.645
1.00	0.619	0.624	0.628	0.633	0.637	0.641	0.648
1.20	0.620	0.626	0.632	0.636	0.641	0.646	
1.40	0.622	0.629	0.634	0.640	0.644		
1.60	0.623	0.631	0.637	0.642	0.647		

Note: The head given is the effective head, H+1.4 h. When the velocity of approach is small, the term h may be neglected.

head vary with locality and the miner's inch is not of fixed value. It is commonly taken, however, to mean that amount of water that will flow through an orifice 1 in. square under a head of 6.5 in., the discharge being measured in cu. ft. per min. or in gal. per day.

The coefficients of discharge for square vertical orifices are sufficiently different from those that apply to orifices of circular verticality that the coefficient that will approximate the mean value will be found to be 0.624. The formula becomes:

$$Q = \frac{0.624 \times 8.02}{144} \times \sqrt{\frac{6.5}{12}}$$

$$= 0.0256 \text{ cu. ft./sec.}$$

$$= 1.536 \text{ cu. ft./min.} = 16{,}547 \text{ gal./day.}$$

This value is commonly taken as that of the miner's inch as specified above to be most frequently accepted.

Weir Measurement

In the gasoline plant and refinery, weirs are extensively used and the measurement of flow across them is quite often desired. Weirs are dams or obstructions placed across a stream for the purpose of diverting the water or liquid in such a manner that it will be caused to flow through an opening in the obstruction. This opening may take several forms. Weirs are divided into two classes, those with and those without end contractions. Weirs with end contractions are most generally used.

A weir with end contractions is one in which the ends or sides of the notch is less than the width of the channel and shallower than the depth. In a weir of this type, there will be found a contraction of the issuing stream at the bottom and two sides.

A weir without end contractions is one in which the notch is as wide as the full width of the channel and shallower than the depth. In a weir of this type there is only a contraction at the bottom of the issuing stream. A means for the admission of air under the issuing sheet of water must be provided, otherwise there will be formed a partial vacuum that will tend to increase the discharge.

The edge of the weir over which the stream flows is called the crest of the weir. The inner edges of a weir of either type should be sharp so that the issuing stream will touch only a sharp distinct edge. For ordinary work the beveling of the weir at a 30-deg. angle is recommended. The weir must be set perfectly level and the edge of the weir crest must be straight and smooth. The edges of an end contracted weir must also be beveled and straight and perpendicular to the crest.

The head is the vertical distance from the crest of the weir to the surface of the water. The head should be measured upstream at such a distance that the curve caused by the water flowing across the weir will have no influence on the measurement. The water flow should contact the weir with as little velocity as possible.

If we let L equal the length of the weir in ft., and H equal the measured head in ft., we have for the theoretical discharge Q for an ordinary weir or rectangular notch:

$$Q = 5.347\, L\sqrt{H^3} \quad . \quad . \quad . \quad . \quad (10)$$

For the determination of the actual discharge it is necessary to introduce the coefficient of discharge into the formula, which gives us:

$$Q = 5.437\, C_d\, L\sqrt{H^3} \quad . \quad . \quad . \quad (11)$$

These two formulas apply only in cases where the velocity of approach is such that it may be neglected.

If the velocity of approach (that velocity with which the stream approaches the weir) is such that it will affect the actual measurement of discharge, it becomes necessary to determine the mean velocity with which the stream moves in the channel, and the velocity head. If we let H equal the head as measured at some point upstream from the weir and v equal the mean velocity with which the stream is moving, $h = \frac{v^2}{2g} = 0.01555\ v^2$ will be the velocity head. The effective head would then be equal to H + h, and the theoretical discharge would be found by formula:

$$Q = 5.347\, L\sqrt{(H+h)^3} \quad . \quad . \quad (12)$$

The actual discharge must be figured by formula:

$$Q = 5.347\, C_d\, L\sqrt{(H-nh)^3} \quad . \quad (13)$$

C_d is the coefficient of discharge and n an empirical constant factor introduced to allow for resistances at the edges of the weir. For weirs with end contractions this factor n has a value of 1.33, whereas for weirs without end contractions the value of n is 1.4. The value of the coefficient C_d will be found in Table 1, "Coefficients of Discharge for Weirs With End Contractions," and Table 2, "Coefficients of Discharge for Weirs Without End Contractions."

Example: What is the discharge of a canal if the length of the weir is 5 ft. and the head 8 in. if the velocity of approach is 0?

Solution: H = 8 in. = 0.6667 ft.
L = 5 ft.
K = 0.6067 (by interpolation, Table 1)

$Q = 5.437\, C_d\, L\sqrt{H^3} = 5.437 \times 0.6067 \times 5\sqrt{0.6667^3} = 9.16$ cu. ft. per sec.

If the velocity of approach must be taken into consideration, the solution is first obtained by using the same formula as used above in this solution. This approximate value is then divided by the area of the cross-section of the entire channel, A, in this way obtaining the approximate value of the velocity of approach, that is, $v = \frac{Q}{A}$. After having the value of v, h can be obtained by using the formula, $h = 0.01555\ v^2$, and the effective head can then be found. The more exact value of Q may then be found by using formula 13.

Many times it is desired to obtain the flow by means of a triangular weir. This type weir has a notch cut in triangular form. It is used for the determination of small flows when the head varies between the lower and upper limits of 0.02 and 1.0 ft. The coefficient for this type weir does not vary so radically as it does in the cases of rectangular weirs so a mean value can be applied. A right-angle triangular weir that has the edges chamfered to a sharp line on the inner sides must be used. When the head falls within the above-stated limits, the formula for discharge in cu. ft. per sec. when the head is expressed in ft. is:

$$Q = 2.54\sqrt{H^5} \quad . \quad . \quad . \quad . \quad . \quad (14)$$

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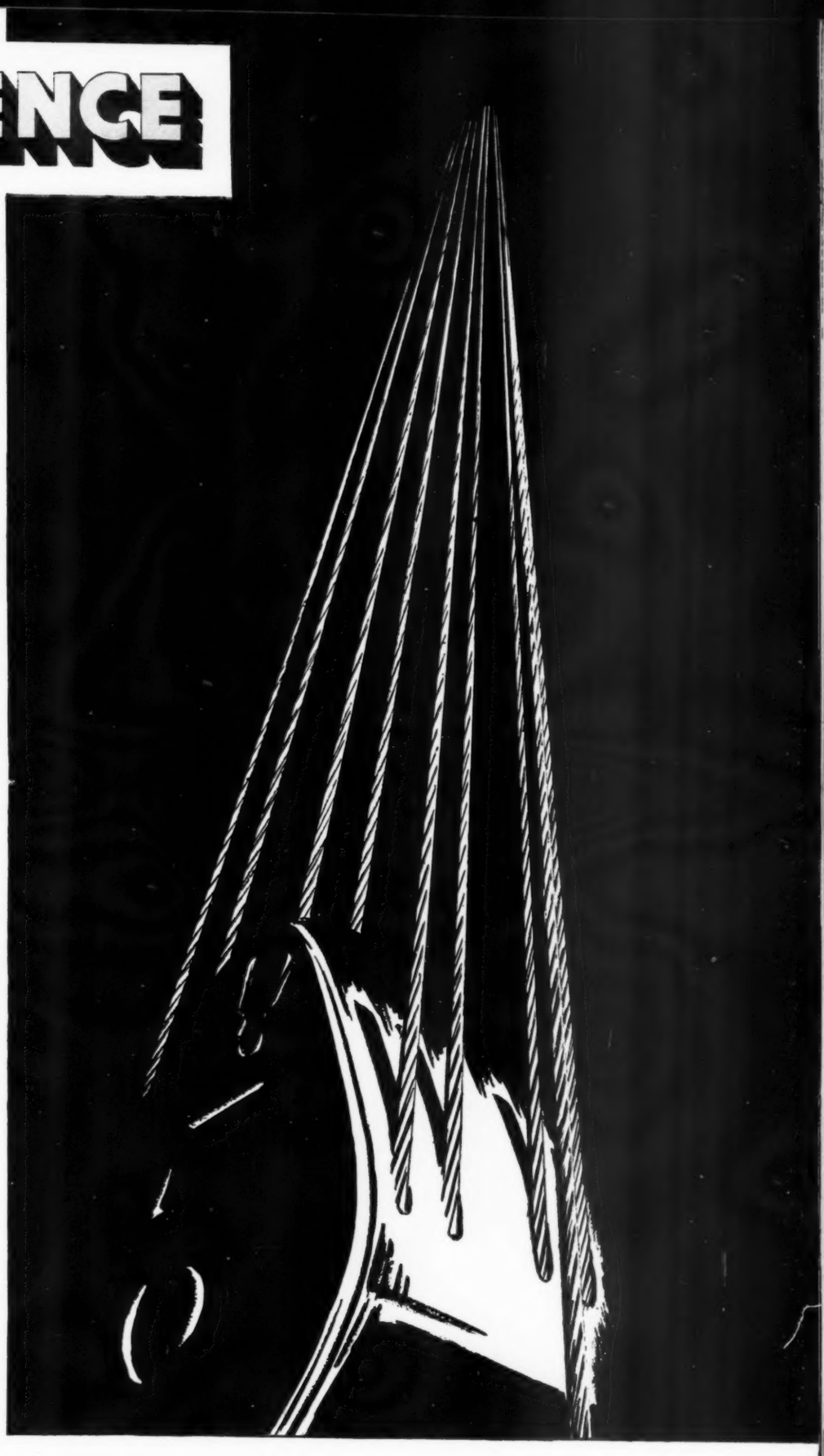

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Data on Availability of Drilling Equipment Materials

by Brad Mills

Executive Secretary, American Association of Oilwell Drilling Contractors

THE shortages of aluminum, lead, copper, nickel, and steel have not seriously inconvenienced the drilling industry, but the regional office of the O. P. M. believes that these and other basic materials will become more difficult to obtain as the rearmament program progresses. The situation as to allotments and priorities shifts weekly, as the supply and demand of raw products shift.

Supply companies report that an acute shortage of several drilling equipment items may be avoided if contractors will accept delivery on equipment not of the latest type. Utilization of present stocks, even if slightly obsolete, will help to relieve current shortage and reduce time orders that carry limited priorities.

A survey of inventories has shown that it is possible to obtain immediate delivery on some of the older type boilers, steam engines, and slush pumps, but difficult where the purchaser demands the latest streamlined model. One supply company can furnish 18-in. slush pumps in quantity, but many operators insist on the 20-in. models for heavy service. The 12 by 12 steam drilling engines are readily available, but the 14 by 14 models are very scarce. Old type boilers may be purchased easily.

Supply houses hold that use of new but outmoded equipment now on hand may help to prevent a genuine shortage of several basic items. The desire to move old inventories is not altogether selfish on the part of the seller. When a pump, boiler, engine, or heavy item of any kind is available and capable of doing a job, obsolescence may be a secondary matter. A drilling contractor should not be blamed for his desire to purchase the latest equipment, as it is often difficult to obtain replacement parts for the older models. Use of obsolete equipment may also affect a contractor's standardization program.

The shortage of alloy steels has affected delivery of drilling pipe, casing, tool joints and other items employing the various alloys. Manufacturers have been able to substitute steels where service is not too severe.

An acute shortage of internal-combustion engines for prime movers has developed. The use of forged crankshafts in engines of this type has caused this shortage. Equipment for forging steel is being utilized for purposes very high on the priority scale.

BRAD MILLS

was made executive secretary of the American Association of Oilwell Drilling Contractors in March of this year—For 16 years previously he had been associate editor of *The Oil Weekly*—Makes his headquarters in Dallas, Texas.

Materials for manufacturing certain parts of power pumps are difficult to obtain and deliveries on the finished products are very slow. Stocks of rotary chains in the best grades are very limited and deliveries probably will be slow. Dies and small tools of finest alloy steels are especially scarce.

The shortage of lap-welded pipe has been occasioned by the very limited supply of steel plates. One large supply company now is getting promises of 6 to 12 months delivery from the mill on all steel shapes, except plates, which require a very minimum of 12 months. Many shapes are no longer being rolled.

From 60 to 90 days are required for delivery of certain large equipment items manufactured from alloy steels.

Roller bearings of some types are no longer carried in stock and future deliveries require from 3 to 12 months. Rubber allotments for ordinary industries have been reduced by 30 percent, and a 50 percent reduction is expected momentarily. This sharp reduction will affect the supply of rotary hose.

The shortage of magnetos has seriously retarded delivery of ordinary gas engines for pumping operations. One supply house has received a large consignment of 2-cylinder gas engines—without magnetos, but with "magnetos to follow" tags attached.

Orders for special equipment calling for nickel alloys may require as much as 6 months to fill, but ordinary steels are available from current inventories.

Since the enforcement by the government of priorities affecting materials used in the manufacture of certain oil field equipment, drilling contractors are having requests for priority certificates from companies supplying them with replacement parts for pumps, etc. The proper procedure is to fill out Form-PD-1 (Application for Preference Rating). This form when completed should be forwarded to the Priorities Division, Office of Production Management, Social Security Building, Washington, D. C., which office will review the application and issue a preference rating certificate to the supplier, who will fill the order according to this rating. One form must be filled out for each order. Proper forms may be obtained from regional offices of the O. P. M.

A preference rating certificate is a notice to a supplier that an order for certain specified material is to be given preferential treatment so that the delivery date can be met. The highest rating is AA. This can be used only by the Director of Priorities, and then only in cases of urgency. After this, they run in the order: A-1-a, A-1-b, A-1-c . . . A-1-j; A-2, A-3 . . . A-10. Ratings in the B class are also used in some cases.

Although priority aid may be given to important civilian projects, it is not the policy of the Priorities Division to give such aid to nondefense contracts or projects that have no connection with the defense effort, unless unusual circumstances are involved.

The oil industry now has a blanket rating of B-2 or B-3, which is very low on the priorities scale. Some thought has been given to raising the rating to A-10, but no definite action along this line has been reported.

Drilling contractors should anticipate in advance the need for items that may soon fall under the restricted list. In this way they will protect themselves from delayed deliveries when actual shortages arise.

Texas and New Mexico Field Scenes

1. *Crew of Noble Drilling Company rig in Hobbs, New Mexico, townsite. Left to right: Bill Burnett, Fred Cox, Ray Robinson, driller, and D. R. Martin.* **2.** *A group of Continental Oil Company men at Hobbs, New Mexico. H. Dailey, engineer (left), P. Q. Chapman, engineer; Fred Clement, engineer, and Edward P. Keeler, district engineer.* **3.** *Taken on an Humble rig in Wasson field, Texas. Left to right: Ben Hilliard, West Texas manager Byron Jackson Company; Paul McFadden, district engineer for Humble; Red Ayres, driller; S. H. Breland; M. J. Bradley; C. H. Oberg, and Jeff Crane.* **4.** *Another Noble Drilling Company crew on townsite well, Hobbs, New Mexico. Left to right: Prim Roady, driller, Lee Collyer, M. Leo Nichols, J. D. Christner, and John Cowling.* **5.** *Ohio Oil Company men at Hobbs, New Mexico. J. H. Hemphill, cashier, (left); C. A. Hitt, land department; W. H. Doty, clerk, and N. E. Trumbull, district engineer.* **6.** *E. M. Stearmer, driller, Osage Drilling Company; J. W. (Whit) Rogers, superintendent, E. F. (Ed) Moran Drilling Company; H. W. Kirby, Reed Roller Bit Company, and Russ Williams, Baash-Ross Tool Company. Picture taken in Wasson field, West Texas.* **7.** *Drilling crew on T. and P. rig in Slaughter area, West Texas. Jack Henderson (left), S. R. Phariss, C. L. Bruce, driller, and Carl Wahlenmaier.*

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Honored for Defense Work

Cameron Iron Works, Houston, Texas, has been honored with the "Navy E" by the Bureau of Ordnance, U. S. Navy Department, the highest service award the navy can make, in recognition of its excellent work on the defense program. The company is ahead of schedule in the manufacture of projectors for depth bombs.

1. *Capt. T. A. Thomson, Jr., commandant of the Eighth Naval District, presents the coveted U. S. Navy's Bureau of Ordnance Flag to Edmund L. Lorehn, vice-president and general manager of Cameron Iron Works, Inc.* **2.** *After the ceremony, employees of Cameron Iron Works file past two Naval officers to receive "E" badges.* **3.** *Charles William Hughes, Sr. (right), a toolmaker at Cameron Iron Works for 14 years, receiving "E" badge, a lapel emblem, authorized by the U. S. Navy for excellent work in defense production. Commander D. D. Dupre, head of the naval reserve officers' training corps unit at Rice Institute, is presenting the emblem.* **4.** *Honored guests from the U. S. Navy and Army seated on the speakers' platform. Edmund L. Lorehn making acceptance speech.* **5.** *Among the distinguished guests present were, left to right: W. St. John Garwood, Houston attorney and master of ceremonies; W. S. Cochran, president of the Houston Chamber of Commerce; Commander D. D. Dupre, U. S. Navy; Mrs. H. S. Cameron, wife of the late founder of Cameron Iron Works; Edmund L. Lorehn, vice-president and general manager of Cameron Iron Works; Capt. T. A. Thomson, Jr., Commandant of the Eighth Naval District; Miss Thomson, and Lt. J. D. Miller, U. S. Navy.*

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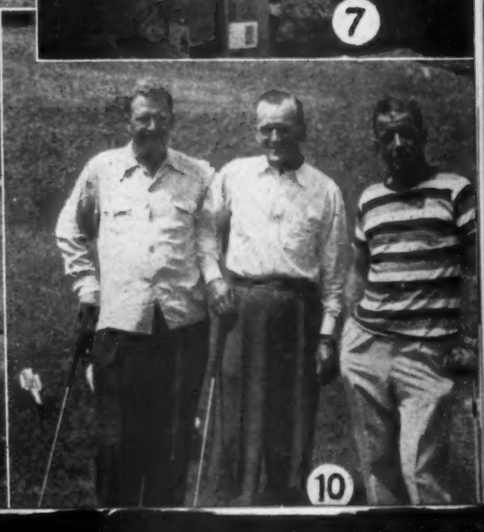
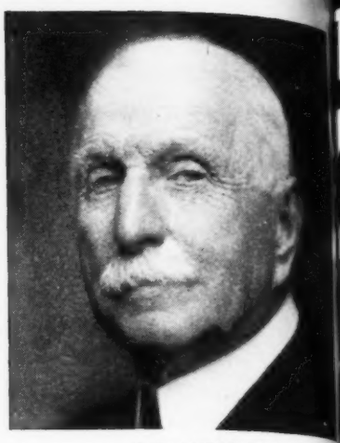


Los Angeles Nomads Golf Tournament and Barbecue

1. Walter Bitterling, foreign visitor; H. P. Larkin, Lou Bronzan, of Baash-Ross, and Zell Harshton waiting for priority on the next hole. **2.** *Hans Ross, of Baash-Ross, C. S. Perkins, Union Oil Company, Bill McGraw, Western Pipe and Steel Company, and Percy Hayes, Universal Consolidated Oil Company, were four of the most intrepid golfers at the outing.* **3.** *Elmer Smith of Lane-Wells and Ernie Fowks, of Emsco and president of the Los Angeles Nomads, smoke peacefully while reflecting over what must have been a low score.* **4.** *Clarence Davenport and Hi Cassidy, McCarty Company, Cy Fluor, Foy Schlettler of Abegg and Reinhold, and Jack Ballagh are happy about the day's shooting.* **5.** *The crowd gathering at Shell's barbecue pits.* **6.** *Abbe Jenks, formerly with Fullerton Oil Company, does a follow through in slow motion.* **7.** *Don't know why Hi Cassidy is holding up two fingers unless, being an advertising agency man, he is signaling for 2 percent cash discount. Rod Durkee of Lane-Wells smiles knowingly.* **8.** *Ready to call it a most enjoyable day: Dave Bradberry and George Trembley, Howard Supply Company, Shell's E. R. Price, and J. A. Wilcox of S. R. Bowen Company.* **9.** *W. T. Archer and Morris Smith prepare to tee off.* **10.** *Al Godfrey, Youngstown's Herb White, and Crane Company's Hal Leedy.*



C. W. LEVALLEY

one of the founders of Chain Belt Company. He invented the first chain manufactured by the company.

J. C. MERWIN, *President*
Chain Belt Company

Fiftieth Anniversary of Chain Belt Company

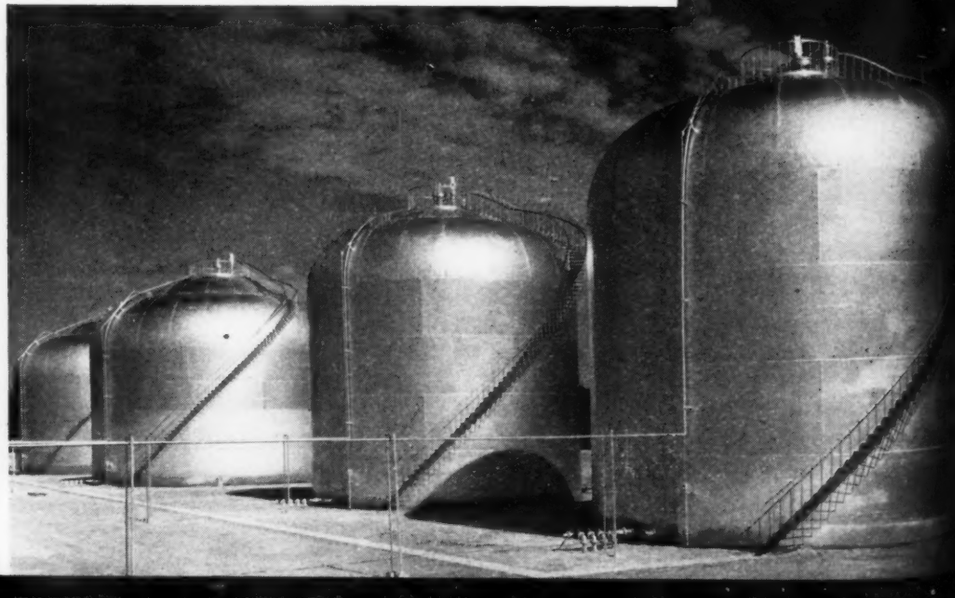
On September 8, 1941, Chain Belt Company, Milwaukee, Wisconsin, observed its fiftieth anniversary. Founded in 1891 for the purpose of manufacturing an improved type of detachable chain, then used largely on agricultural machinery, the company has since expanded its activities and is one of the largest makers of chain belts, construction machinery, elevating and conveying equipment, and related products.

The growth of the company is graphically revealed by comparing the picture at the right and the one at the top of the page. From 1892 to 1902 the second floor of the frame structure housed the offices of Chain Belt Company; the shops were to the rear. In addition to the West Milwaukee Works (top of page), there are also plants at Milwaukee, Springfield and Worcester, Massachusetts.

Tom Workman of California Portland Cement Company (left), Roy Preston, foreman, and Jim Creed, assistant superintendent for Halliburton Oil Well Cementing Company, watch cleaning-up of Robert S. Lytle's well, Anderson No. 1, Los Angeles, California, after freak blowout that was believed caused by earthquake.

R. E. Whitten (left), store manager at Borger, Texas, for The Bovaird Supply Company, and D. C. Kennedy, district manager.

A group of Hemispheroid storage tanks at the Cotton Valley, Louisiana, cycling plant of the Cotton Valley Operators Committee.



The Job —To Pump Seven Million Barrels of Oil

For Power —Two *Superior* GAS ENGINES

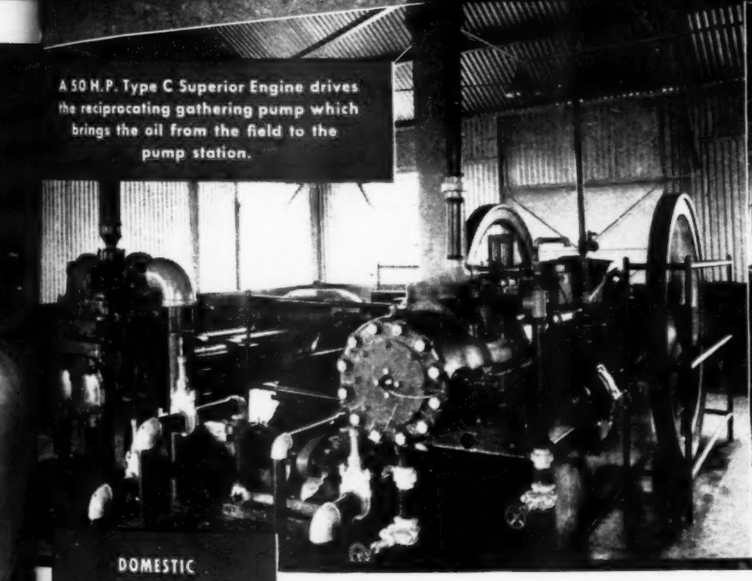
For three long years...day after day... week after week...two Superior Gas Engines have supplied power for the pumps in the East Whitepoint Station of the Republic Pipe Line Company until seven million barrels of crude have gone through a six-inch line to Corpus Christi six miles across the bay.

With never an enforced shutdown, and never a repair bill, the typically faithful performance of these two sturdy Superiors has again demonstrated their outstanding ability to operate with a maximum of rugged dependability and a minimum of maintenance.

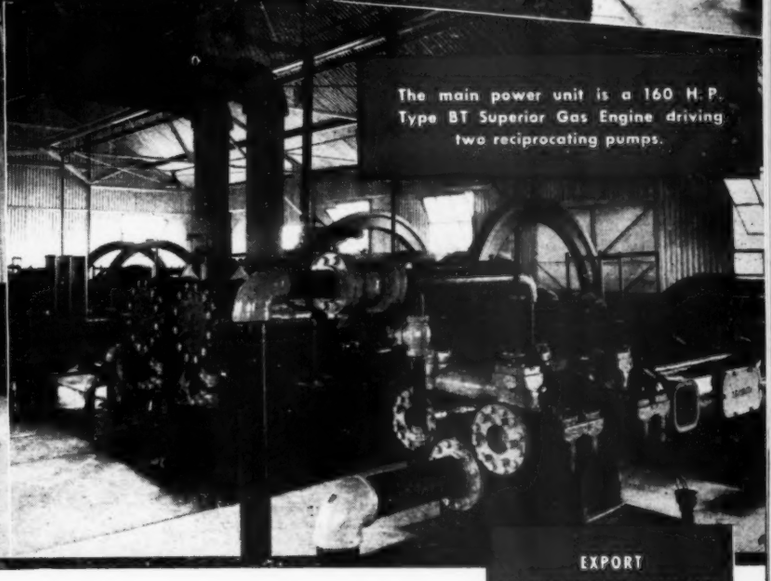
★ ★ ★

Republic Pipe Line pump station at East Whitepoint, Texas, where three pumps driven directly by two Superior Gas Engines have handled seven million barrels of crude oil in three years.

This end view shows how the 160 H.P. Type BT Superior Gas Engine is connected directly to the two main oil pumps. The engine's cooling water pump is driven through V-belts.



A 50 H.P. Type C Superior Engine drives the reciprocating gathering pump which brings the oil from the field to the pump station.



The main power unit is a 160 H.P. Type BT Superior Gas Engine driving two reciprocating pumps.

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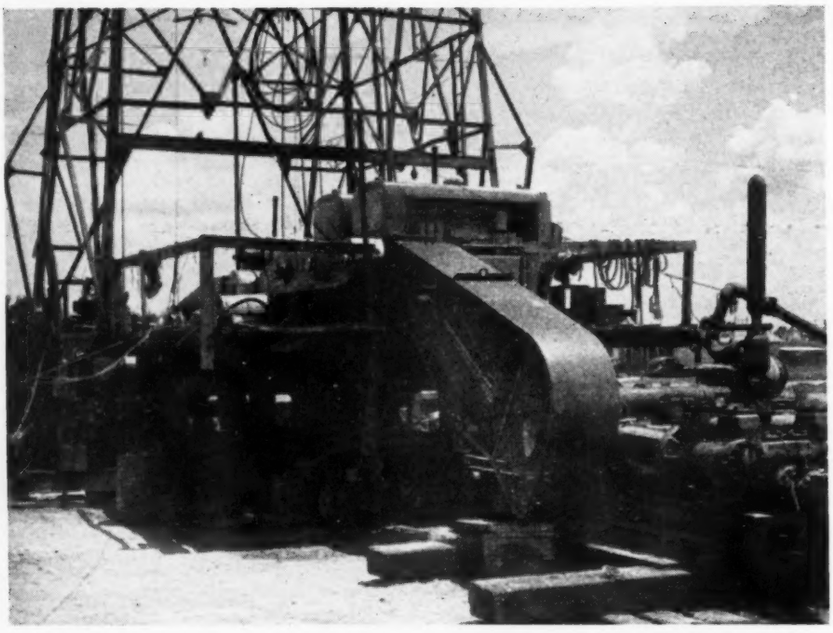


Fig. 1. General view of the new two-engine rig layout

PETROLEUM ENGINEER Exclusive Feature

by

H. Lee Flood

Associate Editor

Water Used to Drill-in Lime Wells in West Texas-New Mexico Area

Wells are drilled with light-weight, streamlined equipment and clear water is circulated while drilling-in to avoid injury to flowing capacity of well.

ALTHOUGH the greater amount of drilling activity in the West Texas-New Mexico area is concentrated in the newer fields such as Seminole, Wasson, and Slaughter in the northern part and in the Imperial region in the southern part of the area, a considerable volume of work is represented by scattered drilling in older fields throughout the area.

Typical of this type of drilling is a well recently completed in Hobbs townsite. Once the most important field in New Mexico, Hobbs is now relatively quiet, being fourth in production in the state in 1940, with 3,790,477 bbl.[1] Production in the Hobbs field comes from the White Lime, of Permian age.

The townsite well recently drilled was completed in 15 days, including the time required for setting casing. Although the well itself is relatively unimportant, being only a routine operation, the equipment used in its drilling is one of the newest rigs in use in the area and is an example of the light-weight, streamlined assemblies now gaining in popularity for drilling to 5000-ft. depths.

After 175 ft. of 9⅝-in. casing had been set and cemented, the well was drilled to a depth of 4201 ft., using fifteen 8¾-in. rock bits. The 5½-in. oil string was set at a depth of 4128 ft. and cemented with 518 sacks of cement. Approximately 11-lb. mud was used during the drilling. Weight of 8 to 10 points is usually carried on the bit by drillers in this area.

While waiting for the oil string cement to set, the drill pipe was laid

[1]Petroleum Development and Technology. Published by the Petroleum Division, A.I.M.E.

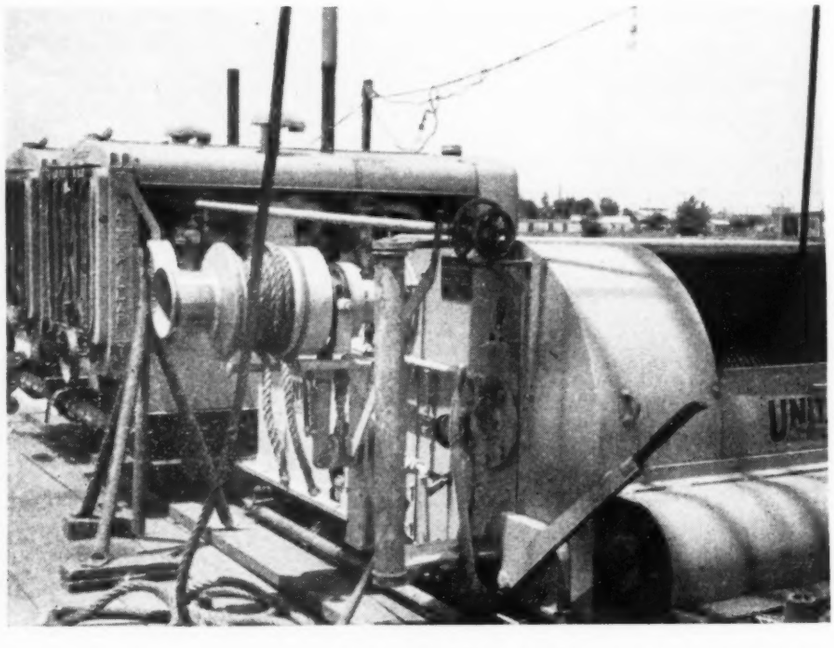
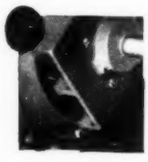


Fig. 2. Quiet, flexible operation characterizes modern semi-portable drilling rigs

HERE it is—your "cast-iron" answer to the splashing water and spattering liquids that make motor operation uncertain in many places. It gives you greater-than-ever protection in three important ways:



Extra Protection . . . against physical damage

One-piece cast-iron frame and end shields completely encase the motor, and offer formidable resistance to rust and corrosion. Ventilating openings are well baffled and contours of the motor shed direct-splashing water or liquids. The low-velocity air intake minimizes sucking in of the spray. Conduit box is waterproof.

Extra Protection ... against electrical breakdown

In the coil windings, the combination of Formex wire, a *special* synthetic-resin bond, and a tough external coat of Glyptal 1201 Red sets a new standard for resistance to moisture and to vapor in the air.

Extra Protection... against wear and tear

Completely enclosed ball bearings of high load-carrying capacity are standard. A cast-iron enclosure protects the bearing and its lubricant. A simple but effective seal along the shaft excludes liquids from the bearings.

In addition to these "extras," you get basic improvements in operating characteristics, convenience in installation, and clean-cut, compact design. Write today for Bulletin GEA-3595. Specify Tri-Clad on your next splashproof-motor order. General Electric, Schenectady, N. Y.

ASK ABOUT

TRI CLAD

Splashproof MOTORS

Where wetness is a factor . . .

. . . and in some outdoor locations splashproof motors may be the answer. Ask your G-E representative about Tri-Clad splashproof motors.

GENERAL ELECTRIC

TSO-TE-5053

Fig. 3. Auxiliary generator driven from drawworks shaft

Fig. 5. Automatic jet-type oiler in air supply line to drawworks clutch

down and preparations made for drilling-in the well using tubing as drill pipe.

Clear water was circulated while the well was drilled-in. Every effort is exercised in completing wells in the Permian limestone sections to avoid plugging the formation with mud or any material that might reduce the flowing capacity of the well. Clear water, having less weight than mud, will impose less pressure against the formation.

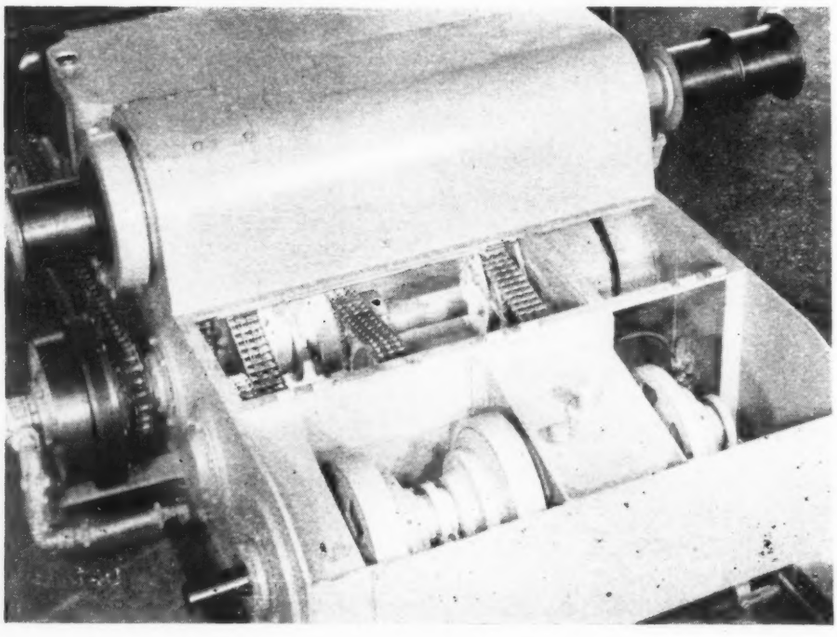
A 4¾-in. rock bit and a 2-ft. drill collar sub were used on the tubing drill string and a 3-in. kelly was used to rotate the pipe while drilling-in. Approximately 3 points of weight was carried on the tubing.

Drilling Rig

The rig used in drilling this well had drilled three other wells, making a total of 19,500 ft. drilled since its purchase.

The equipment is exceptionally quiet in its operation and the ease with which the drawworks may be manipulated is an important factor contributing to its flexibility.

Fig. 4. Interior view of drawworks



The compact arrangement of the equipment including the mud pump is shown in Fig. 1. The drawworks and the two engines supplying power for the rig, shown in Fig. 2, are mounted on one skid for easy portability.

Safety in operation of the equipment is promoted by having all transmission including the drives to the table and to the pump totally enclosed.

At the driller's stand within easy reach are the throttles whereby the engines may be controlled separately or compounded. Six speeds are available in both the hoisting drum and rotary table; all are controlled by a single lever at the driller's side.

In addition to the regular light plant, an a-c. generator has been mounted on the derrick floor and is driven by V-belt from a sheave attached to one of the drawworks shafts, as shown in Fig. 3.

The clutches used on this equipment are operated by air pressure, which actuates the one moving part in the clutch. Air is admitted to or released from the clutch through the action of a single pedal. Within the clutch are two sets of elements that are engaged when air pressure is admitted to the clutch, thus causing the driven shaft to rotate.

In order to provide adequate lubrication to the clutch, the automatic oiler shown in Fig. 5 is incorporated in the air supply line. The velocity of the air passing an orifice in the oiler causes the correct amount of oil to be picked-up and carried into the clutch. Thus the action is entirely automatic.

TOUGH JOBS?

Not with Flupaco "Groove Seals!"

Wells have a way of losing their talent for trouble under the smooth, efficient performance of Flupaco "Groove Seals"!

These pumps have important construction features that give you more pump dollar value than ever before . . . features such as special *controlled* heat treatment—*hand straightening* of one-piece barrels—*precision honing* of the barrel bore—and close inspection at *every* step . . . *all carried on right in Flupaco's own plant!*

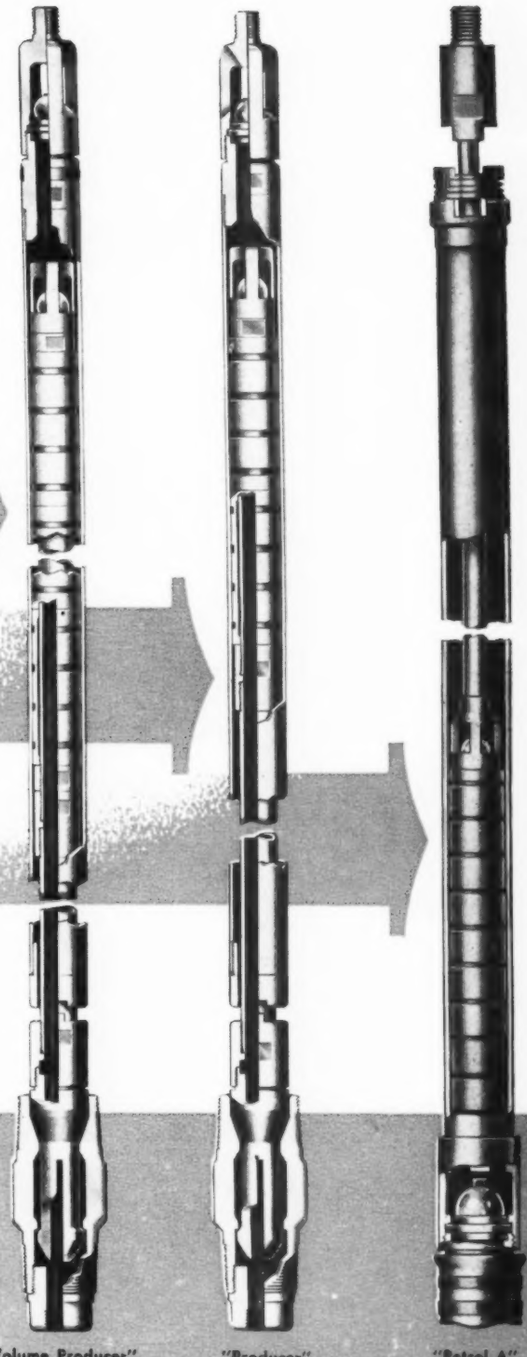
And for your particular pumping problems, "Groove Seals" have *performance* features seldom found in equipment so economically priced . . .

THE VOLUME PRODUCER is simple in construction, easily installed and serviced. It handles a wide range of problems such as large volumes and deep pumping, sand conditions and corrosion, light and heavy oils. Has largest cross-sectional displacement available in insert pumps.

THE PRODUCER "Groove Seal" is a rod pump for medium volumes and depths, and for economical stripper well service. Available in a range of types, sizes and metals to meet almost every pumping condition. Also has largest cross-sectional displacement in insert pumps.

THE PETROL A meets the most exacting needs of stripper well production and shallow depths, even where operating conditions are severe. Simply designed and low-priced, the Petrol A can reduce pumping costs to the core. Made to A.P.I. standards throughout.

All "Groove Seals" are available in the size, type and metal to fit your installation conditions. For a detailed description of Flupaco "Groove Seals" write for your copy of new illustrated catalog which gives full information on the Flupaco line. Or—contact your nearest Fluid Packed representative *today!*



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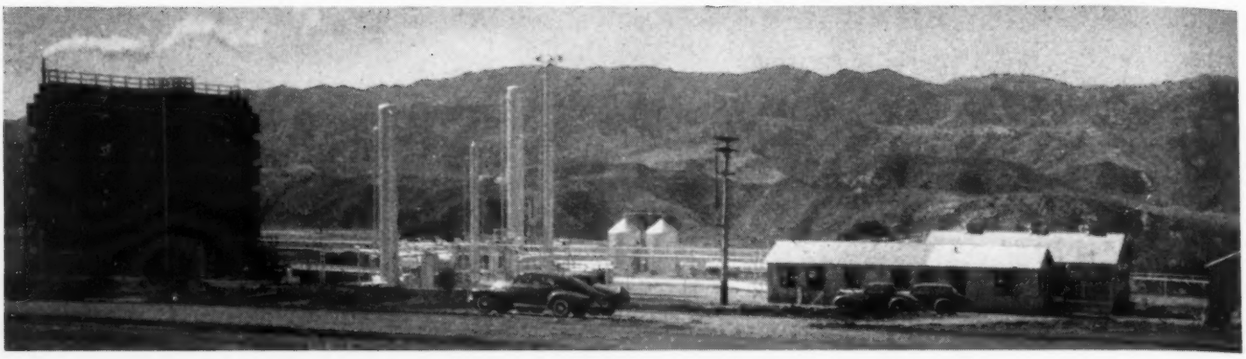
WORLD'S LARGEST **EXCLUSIVE** OIL WELL PUMP MANUFACTURERS



Del Valle Gasoline Company's plant near Saugus, California

Reabsorber in Gasoline Plant Controls Pressure of Entire Distillation System

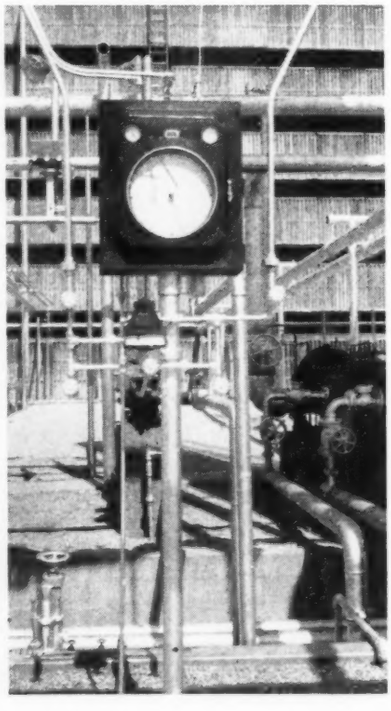
PETROLEUM ENGINEER Exclusive Feature

☆ **Single back-pressure controller serves to maintain constant pressure on system, thus simplifying control problem**

THE new plant of Del Valle Gasoline Company, recently built by Parkhill-Wade of Los Angeles, California, has a gas processing capacity of 15,000,000 cu. ft. at an absorption pressure of 400 lb. per sq. in. Two absorption pressures enter into the operation of this gasoline plant. The first is the raw field gas processing pressure of 400 lb., and the second is the vapor absorption, which is conducted at 40 lb., operating on gases and vapors released from the fat oil tanks, vent tanks, and accumulators. Flow tank gases from the surrounding oil field are collected in a gathering system and boosted to 400 lb. with gas-engine-driven compressors so that the residue may be shipped by pipe line as industrial and domestic fuel.

The products manufactured from the field gas are the usual specification natural gasolines, commonly stabilized to a R.V.P. (Reid vapor pressure) of 21.9 lb., and various R.V.P. specification L.P.G. (liquefied petroleum gases), residue gas for sale, and fuel for the plant itself. The flow through the plant follows more or less the conventional method, employing countercurrent absorption oil contact, and steam distillation of the fat oil. The method that is not so conventional is the practice of controlling all pressures, other than the main absorber pressure, with the reabsorber, which, with its single back-pressure controller, maintains a constant pressure on all vessels and vent tanks through the distillation system and condensate until it enters the pipe line leading to pressure storage.

Controller and indicating flowmeter on cooling tower



Multistage centrifugal pumps driven by steam turbines circulate approximately 16 gal. of absorption oil through the main absorber for each 1000 cu. ft. of gas processed. Reciprocating steam pumps handle the low-pressure oil circulation to the reabsorber, taking suction on a surge tank common to both the high-pressure and low-pressure oil systems, and the streams of fat oil from both absorbers enter a common still for stripping. The fat oil from the high-pressure absorber flows first through a high-pressure vent tank to eliminate dissolved methane and ethane, and then to a low-pressure vent, to exchangers and the preheater to the still.

Still vapors fractionated to end point flow through atmospheric cooling sections to be condensed, and then flow back to the accumulator where the uncondensed vapors pass directly to the reabsorber without flowing through pressure-controlling equipment. The pressure carried on the reabsorber is controlled with an instrument that holds the desired pressure, backing up through all the previous vessels to maintain a constant pressure without additional pressure reducing or controlling equipment. Uncondensed vapors that are not absorbed on contact with the oil in the reabsorber flow

Sub-Surface CONTROL... a MUST with HIGH PRESSURES

OTIS REMOVABLE BOTTOM HOLE REGULATOR

Production bottlenecks such as freezing surface connections, dangerous high working pressures and costly surface heaters are all positively eliminated by the installation of an Otis Removable Bottom Hole Regulator.

The point of pressure reduction is moved from the surface connections to a depth of several thousand feet where bottom hole temperatures completely absorb all temperature loss due to gas expansion. This operation produces a natural "mile long" earthen heater that is the most practical heat exchanger known.

A variable rate of production ranging from 0 to 5 million cu. ft. per day under the same predetermined low flowing pressure is had merely by regulating the surface choke. The opening through the regulator changes automatically to allow whatever rate of flow is required at the surface.

Besides positively eliminating freezing of the surface connections, the working pressures are reduced to a safe predetermined workable limit.

The regulator is run and pulled under pressure on an ordinary steel measuring line and requires only a few hours for the complete installation.

Write or call your nearest Otis representative for details.

Write for complete information and details

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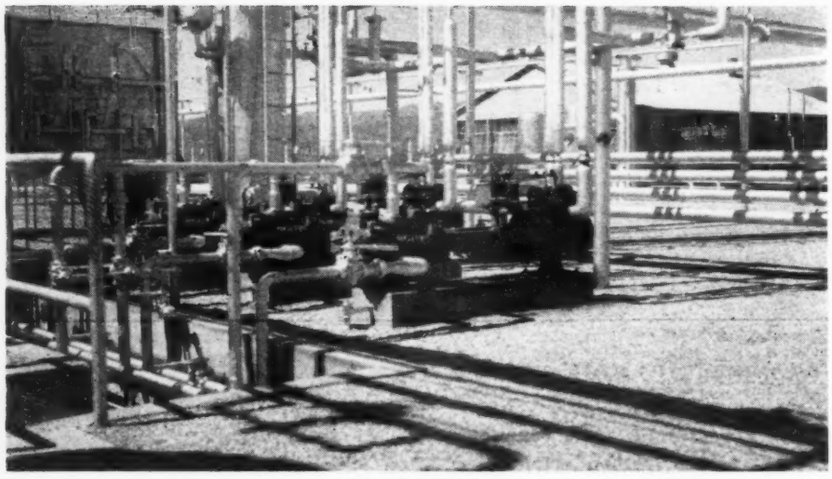


Close clearance simplex steam pumps

to the boilers of the plant for fuel, instead of being recompressed for shipment with the usual residue from the main absorbing column.

The raw gasoline from the still accumulator is pumped to the 24-in. by 55-ft. fractionator, operated at 200 lb. to manufacture the 21.9-lb. gasoline. Overhead condensate is pumped back to the column at a rate of 3:1 to produce the desired R.V.P. gasoline. The excess overhead, when condensed, produces L.P.G. which is employed as liquid fuel for various purposes and sold as such.

The ground plan for the plant was adapted to the surface of the lease when constructed, placing the plant boilers in the extreme southwest corner, which is the lowest point in the yard. Drainage in the southeast corner decided where the plant pressure storage tanks were to be situated, so that no accident can occur that might cause damage to other parts of the plant higher up the slope.

Following the latest development in natural gasoline practice and design, all plant and plant process piping is placed above the ground level, either carried on low concrete piers or on pipe and structural steel supports to allow for adequate head room. Welded fittings are employed almost exclusively to eliminate pipe-line leaks and to obtain the smoothest flow of the commodities when the lines change direction. If not practicable to support the piping aboveground, concrete lined trenches are used so that all piping can be readily inspected and maintained without digging.

P 532.4

Heat-Treating Crystallized Tubing to Decrease Breakage

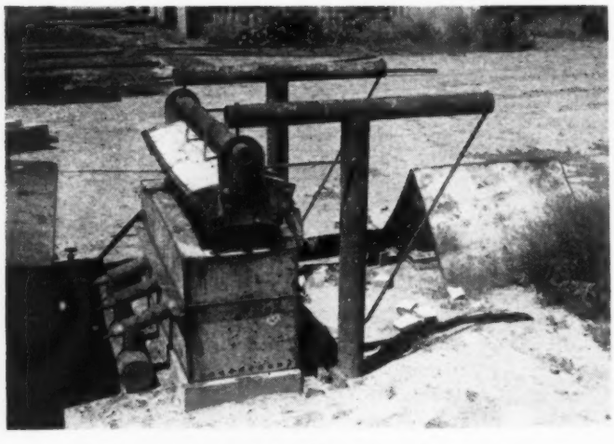


Fig. 1. Furnace for heating tubing ends

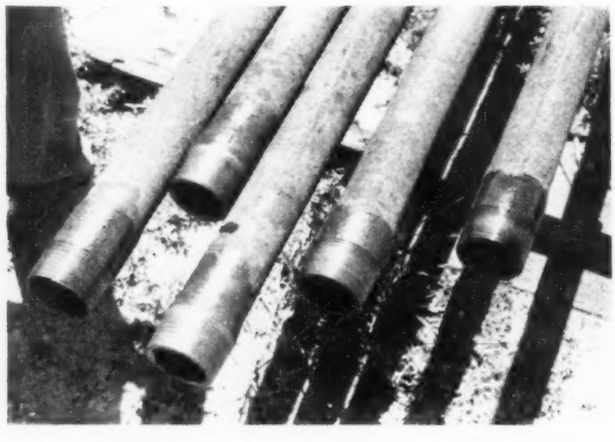


Fig. 2. Rethreaded 2-in. upset tubing after normalizing

IN VIEW of the present shortage in tubular goods and the importance of utilizing all materials to the fullest extent, it is interesting to note the method whereby one West Texas oil company has materially increased the service life of tubing strings.

In nearly every instance when tubing strings had parted, it was noted that the break occurred at the base of the threads, due undoubtedly to a crystallized condition in the metal at this point.

Experiments indicated reheating of the ends of all tubing lengths removed from the wells would restore the metal to a satisfactory condition for rethreading and further use.

Accordingly, the furnace shown in Fig. 1 was constructed so that reheating could be done as a routine job. The sheet iron "tent" behind the furnace houses the blower that supplies an air blast to the 3-burner manifold.

The tubing ends are heated to 1400-1600°F. This region of heat is easily judged by the operator and pyrometer control is unnecessary.

After the heated regions are air-quenched the pipe is rethreaded. The clean appearance of the threads on 2-in. upset tubing is indicated in Fig. 2. The old threaded section is removed, leaving one or two threads to engage the dies. The length of the upset section is sufficient to accommodate the second set of threads.

The cost of this work is surprisingly low and the increased life of tubing has materially reduced the costs of well operation.

This method was developed by F. B. Shepard, Big Lake Oil Company, Texon, Texas.

Program of Petroleum Division A. I. M. E.

Dallas, Texas, October 16, 17, and 18

THE program for the Fall meeting of the Petroleum Division of the American Institute of Mining and Metallurgical Engineers, to be held in the Adolphus Hotel, Dallas, Texas, October 16, 17, and 18, has been announced as follows:

Thursday, October 16

8:00 A. M.—Danish Room, fifteenth floor. Breakfast meeting for authors, presiding officers of technical sessions of the day, and Petroleum Division officials. Subscription 75 cents.

8:30 A. M.—Main floor. Registration of all members, ladies, and guests. Registration fee $2.00 for all except ladies and student associates who will be guests of the East Texas A. I. M. E. Section. Copies of papers, tickets, etc., will be issued at time of registration.

Technical Session

10:00 A. M.—Grand Ballroom. E. A. Stepheason, chairman; T. V. Moore, co-chairman.

Address by John R. Suman, president of the Institute.

"Sampling Gas Wells That Produce Condensate to Determine Chemical Composition and Phase Characteristics," by J. M. Flaitz and A. S. Parks.

"A Chart to Provide Approximate Correction for Temperature and Deviation from Boyle's Law," by A. D. Brokaw.

1:30 P. M.—Grand Ballroom. J. U. Teague, chairman; R. O. Garrett, co-chairman.

"Secondary Recovery Program at Oklahoma City," by Dr. D. L. Katz, University of Michigan.

"Practical Application of Productivity Indices," by W. L. Horner and James A. Lewis, Core Laboratories, Inc.

"Potential Well Testing Technique by Back Pressure Methods in Kansas," by Charles Rodd, Gulf Oil Corporation.

"A Comparison of Marsh Funnel and Stormer Viscosities," by J. E. Owen.

"Natural Gas Hydrates," by Don B. Carson and D. L. Katz, University of Michigan.

6:00 P. M.—Chartered busses leave from main entrance of Adolphus Hotel for home of Mr. and Mrs. E. DeGolyer, "El Rancho Encinal." All who have registered and their wives are invited to attend as the personal guests of Mr. and Mrs. E. DeGolyer. Admission by invitation only, which will be supplied at time of registration.

Friday, October 17

8:00 A. M.—Danish Room, fifteenth floor. Breakfast meeting for authors, presiding officers of technical sessions of the day, and Petroleum Division officials. Subscription 75 cents.

Technical Session

9:00 A. M.—Grand Ballroom. N. N. Jones, chairman; C. H. Keplinger, co-chairman.

"Significance of Permeability Coefficients," by E. S. Burnett, U. S. Bureau of Mines.

"The Unsteady Flow of Gas Through Unconsolidated Sand," by Charles R. Hetherington, D. T. MacRoberts, and R. L. Huntington, University of Oklahoma.

"An Engineering Approach to the Gas Lift Problem," by C. E. Tweedle, Coastal Engineers.

"The Use of Dimensional Models in the Study of Oil Well Performance," by M. E. True and M. C. Leverett, Humble Oil and Refining Company.

Noon—Executive Committee, Petroleum Division, luncheon meeting.

Technical Session

1:30 P. M.—Grand Ballroom. H. F. Beardmore, chairman; S. E. Buckley, co-chairman.

"The Use of Electrical Resistivity Logs to Determine Some Reservoir Characteristics," by G. E. Archie, Shell Oil Company, Inc.

"The Fitts Pool," by K. R. Teis, consulting engineer.

"The Relation of Linear Permeability to the Specific Productivity Index," by Frank M. Pool, Texas A. and M. College.

"The Evaluation of Oil Properties," by W. H. Burke, Shell Oil Company, Inc.

"Pressure-Hydration Relationships in Heaving Shale," by H. H. Power, Barnaby L. Fowle, and Joseph B. Plaza, University of Texas.

7:00 P. M. to 7:45 P. M. —Cocktail party for all who have registered and their wives as the guests of the Dallas Petroleum Club. (Club rooms located in east end of main floor lobby of Adolphus Hotel.)

8:00 P. M. to Midnight—Informal dinner dance in Main Ballroom of Adolphus Hotel for all who have registered and their wives. Tickets must be purchased at registration desk before noon, Friday, October 17.

Saturday, October 18

8:00 A. M.—Danish Room, fifteenth floor. Breakfast meeting for authors, presiding officers of technical session of the day, and Petroleum Division officials. Subscription 75 cents.

Technical Session

9:00 A. M. — Grand Ballroom. "Forum on Reservoir Performance."

This session is sponsored by the Production Engineering Committee, of which A. W. Walker is chairman and who will preside at the session.

"Production Under Effective Water Drive as a Standard for Conservation Practice," by E. DeGolyer, DeGolyer-MacNaughton and McGhee.

"A Study of Edgewater Encroachment in Petroleum Reservoir Sands," by Frank G. Miller, U. S. Bureau of Mines.

Saturday Afternoon

State Fair of Texas will be open. Oil exhibit from New York World's Fair will be on display.

Football game at Fort Worth (32 miles from Dallas), 2:00 P. M., Texas A. and M. vs. Texas Christian University. Tickets may be purchased at registration desk.

Dallas Meeting Committees

General Committee, E. H. Blum, The Atlantic Refining Company, chairman.

Arrangements Committee, W. E. Winn, Sun Oil Company, chairman.

Entertainment Committee, L. E. Tracy, The Oil Well Supply Company, chairman.

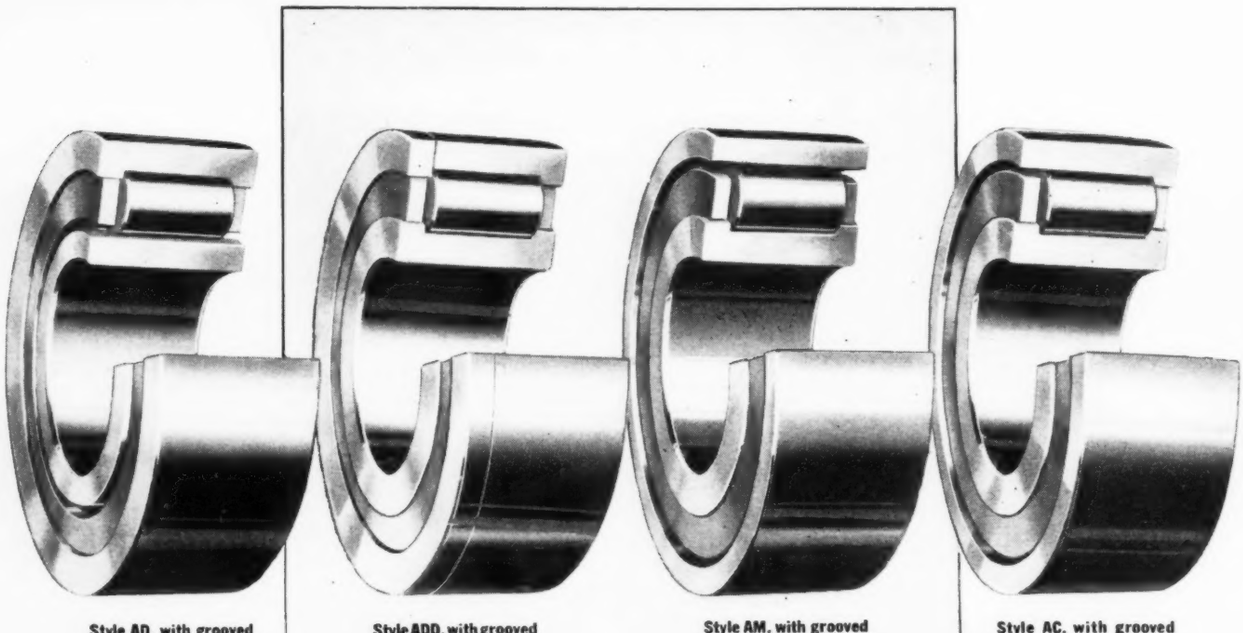
Finance Committee, Lewis W. MacNaughton, DeGolyer-MacNaughton and McGhee, chairman.

Registration Committee, C. B. Carpenter, U. S. Bureau of Mines, chairman.

Publicity Committee, K. C. Sclater, *The Petroleum Engineer*, chairman.

Ladies Entertainment Committee, Mrs. F. H. Lahee, chairman.

(Photographs of officials and speakers appear on pages 149 and 151).



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Petroleum Division, A. I. M. E., Dallas Meeting

JOHN R. SUMAN, Vice-President
Humble Oil and Refining Company, Houston, Texas, and president of the A.I.M.E., will address the meeting

DR. E. A. STEPHENSON
University of Kansas, Lawrence, Kansas, and chairman of the Petroleum Division of A.I.M.E., is chairman of the morning session Thursday

E. H. BLUM, Vice-President
Atlantic Refining Company, Dallas, Texas, chairman of general committee on arrangements

E. DeGOLYER
DeGolyer-MacNaughton and McGhee, Dallas, Texas, past chairman of the Petroleum Division of A.I.M.E., will present paper at morning session Saturday

CHESTER NARAMORE
New York, New York, executive secretary, Petroleum Division of the A.I.M.E.

N. N. JONES
Humble Oil and Refining Company, Tyler, Texas, chairman of East Texas Chapter, Petroleum Division, A.I.M.E. Chairman morning session Friday

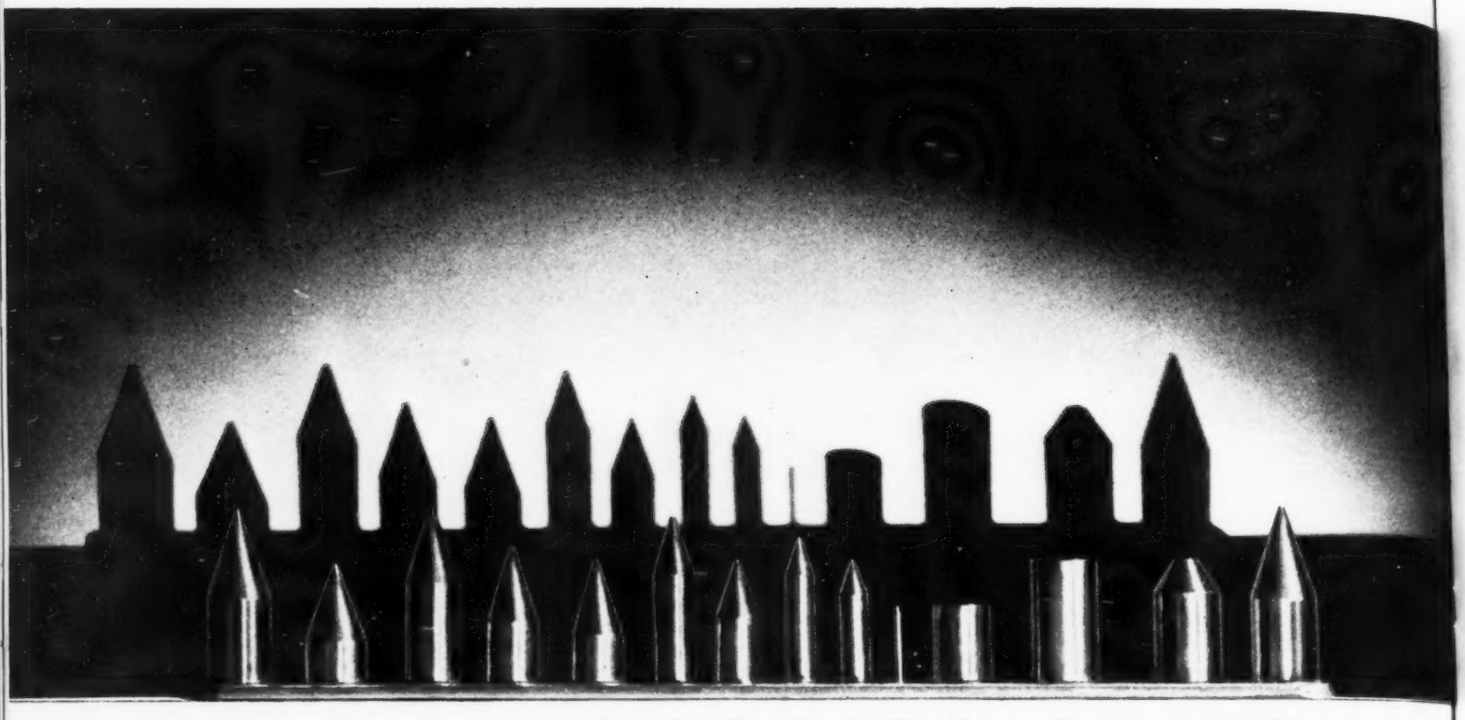
HARRY H. POWER
University of Texas, Austin, past chairman of the Petroleum Division, A.I.M.E., co-author of paper to be presented at afternoon session Friday

J. U. TEAGUE
Hogg Oil Company, Houston, Texas, chairman, afternoon session Thursday

H. F. BEARDMORE
Amerada Petroleum Corporation, Tulsa, Oklahoma, chairman afternoon session Friday

BIG HOLES OR LITTLE ONES

—SHALLOW OR DEEP



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3.	$\frac{15}{32}$x1 $\frac{7}{16}$	Deep Penetration
4.	$\frac{15}{32}$x1$\frac{1}{8}$	Deep Penetration
5.	$\frac{15}{32}$x1	Deep Penetration
6.	$\frac{3}{8}$x1$\frac{3}{8}$	Deep Penetration
7.	$\frac{3}{8}$x1	Deep Penetration
8.	$\frac{1}{4}$x1 $\frac{3}{16}$	Deep Penetration
9.	$\frac{1}{4}$x1	Deep Penetration
10.	$\frac{1}{16}$x$\frac{5}{8}$	Special
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12.	$\frac{9}{16}$x1	Full Mushroom—Flat Nose—Hollow Point
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Petroleum Division, A. I. M. E., Dallas Meeting

C. B. CARPENTER
U. S. Bureau of Mines, Dallas, Texas, chairman of Registration Committee

LEWIS W. MacNAUGHTON
DeGolyer-MacNaughton and McGhee, Dallas, Texas, chairman of Finance Committee

LLOYD E. TRACY
The Oil Well Supply Company, Dallas, Texas, chairman of Entertainment Committee

J. M. FLAITZ
Union Producing Company, Shreveport, Louisiana, co-author of paper to be presented at morning session Thursday

T. V. MOORE
Humble Oil and Refining Company, Houston, Texas, past chairman of Petroleum Division of A.I.M.E., co-chairman morning session Thursday

JAMES A. LEWIS
Core Laboratories, Inc., Dallas, Texas, co-author of paper to be presented at afternoon session Thursday

FRANK G. MILLER
U. S. Bureau of Mines, San Francisco, California, will present paper at morning session Saturday

J. E. OWEN
Geophysical Research Corporation, Tulsa, Oklahoma, author of paper to be presented at afternoon session Thursday

DR. D. L. KATZ
University of Michigan, Ann Arbor, co-author of paper to be presented at afternoon session Thursday

LAUGH WITH BARNEY

Catherine: I shall spend my vacation fishing.

Beatrice: Then why the new bathing suit?

Catherine: That's my bait.

" " "

"Fasten that tunic button, you!" shouted the sergeant-major to the recruit. "We don't want none of that strip-tease stuff in the Army."

" " "

Visitor: And this, I suppose, is one of those hideous caricatures you call modern art.

Artist: No, that's a mirror.

" " "

Policeman: How did this accident happen?

Motorist: My wife fell asleep in the back seat.

" " "

"My uncle hates burglar alarms."

"Why?"

"They interfere with his work."

" " "

Man (handing over his pay envelope to his wife): "You got a nice increase this week, dear."

" " "

"Where is the man who doesn't like to see smiling, cheerful faces around him when things go wrong?"

"You'll find him on any golf course."

" " "

A garlic sandwich is two pieces of bread in bad company.

" " "

In the parlor there were three—
The girl, the lamp, and he.
Two is company, no doubt
That is why the lamp went out.

" " "

She: Can you drive with one arm?

He: Sure.

She: Okay, have an apple.

" " "

"What sort of a chap is he?"

"He has a mechanical mind. He was over to see me last night and the lights went out and he spent the whole evening trying to fix them."

" " "

FOUND: Woman's bag left in my parked car. If owner will pay for this advertisement she can have it. If she will tell my wife how bag happened to be there, I'll pay cost of advertisement. Telephone Jefferson 8100—the quicker the better.

A colored preacher, standing before his flock stared in dismay at the red blotch on his white starched bosom, made by an over-ripe tomato tossed by an unruly member of the congregation. He departed from his prepared sermon about the pearly gates.

"Brothers and sisters," he said softly, "there is gwine to be jes' about ten mo' minits of this hebben business. Then you is gwine to see all hell break loose!"

" " "

"They say swimming is the best thing to develop poise and grace."

"Yeh, didja ever get a close look at a duck?"

" " "

Boy: Say, honey, what have you got on for tonight?

Girl: Nothing I couldn't get out of for you dear.

" " "

"What is a snuff manufacturer?"

"A man who goes around putting his business in other people's noses."

" " "

"How can I make anti-freeze?"

"Hide her woolen pajamas."

" " "

The man at the movies was annoyed by constant talking behind him. "Excuse me," he said, turning around, "but we can't hear a word here."

"You don't say so!" retorted the woman behind. "Well, what we're talking about isn't any of your business!"

" " "

Drunk (to splendidly uniformed bystander): Shay, call me a cab, will ya?

Splendidly Uniformed Bystander: My good man, I am not the doorman; I am a naval officer.

Drunk: Awright, then, call me a boat. I gotta get home.

" " "

And now they're telling about the Scotchman who ate an apple every day except during the two weeks when the doctor was on his vacation.

" " "

A young mother, having had very little time to get to a hospital, gave birth to a child on the hospital lawn. The father was greatly chagrined upon receiving a bill marked "Delivery room and maternity ward, $160." Greatly upset, he wrote to the authorities, carefully explaining that he did not have to pay this fee because of the child having been born on the lawn.

Several days later he received a bill marked "Green fees, $160."

Father (facetiously): Don't you think our son gets his intelligence from me?"

Mother (likewise) He must have. I've still got mine.

" " "

Information Clerk: Madam, this train goes to Omaha and points West.

Madam: Young man, I want a train to Oshkosh, and I don't care which way it points.

" " "

A lawyer was always lecturing his office boy, whether he needed it or not. One day he overheard this conversation between the boy and one employed next door:

"How much does he pay you?" asked the latter.

"I get $5,000 a year," replied the lawyer's boy, "ten dollars a week in cash and the rest in legal advice."

" " "

George: Why does a woman say she's been shopping when she hasn't bought a thing?

Mae: Why does a man say he's been fishing when he hasn't caught anything?

" " "

"Hey, John," called out the service station attendant, "Your doctor is out here with a flat tire!"

"Indeed! A most interesting subject!" came the voice of the boss from the rear of the building. "Diagnose the case as flatulency of the perimeter and charge him accordingly!"

" " "

Explorer: The jungle was all around us. Ammunition, food and whisky had run out, and we were parched with thirst!

Listener: But wasn't there any water?

Explorer: Sure. But it was no time to be thinking of cleanliness.

" " "

"Darling, I could sit here and do nothing but look at you forever."

"Yeah, that's what I'm beginning to think, too!"

" " "

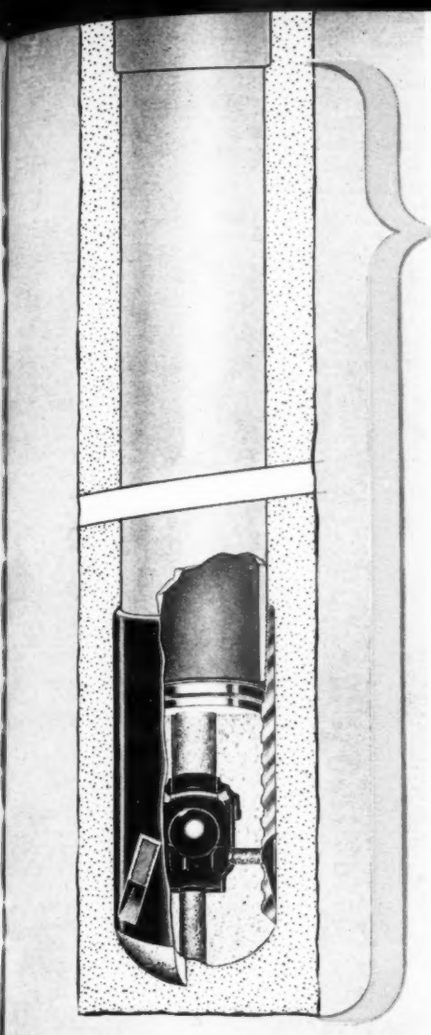
Life isn't very fair to us men. When we are born, our mothers get the compliments and the flowers. When we are married, our brides get the presents and publicity. When we die, our widows get the insurance and the winters in Florida.

" " "

Artist: I'm not going to ask you to pose in the nude today. I want you to wear a costume.

Model: Have you got anything special in mind?

Artist: Yes, getting this picture finished.



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When the fluid strikes the baffled ports in a Baker Cement Wash-Down Whirler Float Shoe or Wash-Down Whirler Guide Shoe, a downward and then an upward whirling motion results. When running in casing, this whirling action provides a means of disintegrating and washing away bridges. When cementing, the whirling motion, imparted first to the fluid preceding the slurry and then to the slurry itself, washes the formation and properly prepares the hole. It then assures best possible distribution of a uniform body of cement around the shoe and the shoe joint. It is this uniform cement distribution that reduces the hazard of channeling to a minimum, and often saves a costly recement job.

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SEE PAGES 222 AND 223 OF THE 1941 BAKER (OR COMPOSITE) CATALOG

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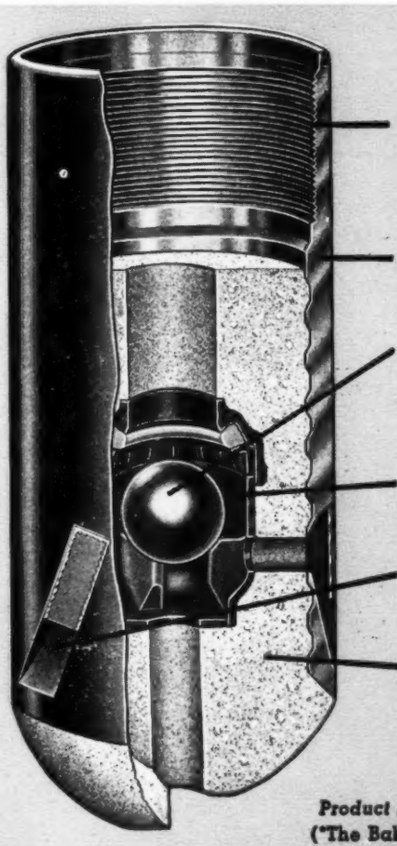

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(2) STRENGTH. The seamless steel casing shoe into which the concrete plug and Plastic BALL-TYPE Valve Assembly are securely anchored, provides a unit that has the STRENGTH to float the longest and heaviest string of casing with an ample factor of SAFETY.

(3) POSITIVE, LEAK-PROOF BACK-PRESSURE VALVE. The buoyant Plastic BALL-TYPE Back-Pressure Valve floats in the cement slurry or rotary mud and instantly forms a leak-proof double seal against a narrow, tough rubber ring (backed by Plastic and concrete) at the slightest reversal of pressure. Here is Valve Efficiency at its best.

(4) AMPLE CIRCULATION AREAS. The correctly designed, *streamlined* Valve Assembly provides passageways ample for any circulating or cementing operation . . . a fact attested to by actual field performance under the most severe operating conditions.

(5) BAFFLED WHIRLER PORTS provide wash-down whirler action so important in washing away bridges, preparing formation to receive the slurry, and securing uniform cement distribution. Here is the ultimate in *Cementing Efficiency.*

(6) EASY DRILLABILITY results from the internal construction of Baker Formula Concrete and Plastic . . . the Plastic BALL-TYPE Valve Assembly being set on end in the concrete plug to present a minimum cross-sectional area to the drilling bit. The concrete and the Plastic are quickly drilled up and circulated out of the hole.

Product No. 120 **— Baker Cement Wash-Down Whirler *Float Shoe**
(*The Baker Wash-Down Whirler principle is also available in a Guide Shoe)

Running Tour

WITH MEN IN THE INDUSTRY

GRADY H. VAUGHN, president of Big West Drilling Company of Dallas, Texas, was recently appointed director

GRADY H. VAUGHN

of producing operations in District 3 by Petroleum Coördinator Harold L. Ickes. Vaughn will make his headquarters in Houston, Texas.

H. F. WINHAM has been transferred from Kilgore, Texas, as division engineer for Shell Oil Company to district superintendent at the company's White Castle, Louisiana, headquarters.

RICHARD M. ZIMMERLY, recently transferred to Midland, Texas, by the Humble Oil and Refining Company, will marry Miss Yvonnie Mae Suggs of Andrews, Texas, September 22. The wedding will take place in Socorro, New Mexico. The couple will reside in Midland.

HENRY WARREN WILSON is now president of the Panhandle Producing and Refining Company, Wichita Falls, Texas. He succeeds the late William Rhodes Davis, Houston, Texas. Wilson was a vice-president of W. R. Davis and Company. It is also expected that Wilson may be named as head of the Davis company with headquarters at Houston.

H. N. GREIS, president of the Deep Rock Oil Corporation, recently awarded 113 employees service emblems for 20 and 25 years' employment.

JAMES ANDERSON, Humble Oil and Refining Company, Houston, Texas, has been elected treasurer of that company. He succeeds R. L. BLAFFER, formerly chairman, who retired August 4.

J. J. STEITZ, JR., and D. L. BARRETT are new assistant managers of the fuel oil department of the Standard Oil Company of New Jersey.

E. L. WILSON, Maracaibo Oil Exploration Corporation, is chairman of the Dallas attendance and golf committee for the Texas Mid-Continent Oil and Gas Association's Convention to be held October 9, 10, and 11 in Beaumont, Texas. Wilson's committee will arrange for the Dallas delegation to attend the meeting and select the local team to compete in the golf tournament.

JOHN PEARCE, Mid-Continent representative of the Colona protector division of the Pittsburgh Screw and Bolt Corporation, was seriously injured in a three-car accident near Olney, Illinois. Pearce suffered a fractured skull, a badly mangled arm, and internal injuries.

HENRY D. LAUDERDALE, Mercedes, Texas, is new chief of the oil and gas division of the attorney general's division at Austin, Texas, succeeding JAMES P. HART, who resigned to enter private practice.

O. B. HAUSAM, drilling contractor, was injured in an auto accident near Coweta, Oklahoma. It was reported that Hausam sustained a broken leg, a broken rib, and several cuts and bruises about his face and head.

JOHN WEIR VANTINE, 84, died of injuries received from an automobile accident. Vantine was a veteran of 72 years experience in the Pennsylvania oil fields and was given the title of "grand old man of the oil industry" at the International Petroleum Exposition in Tulsa, Oklahoma, in 1938.

JOHN W. THOMPSON, Oklahoma City, Oklahoma, driller, was killed when the well on which he was working blew out and caught fire near Guthrie, Oklahoma.

HARLEY PARKS, superintendent of the Sun Oil Company in West Texas, drowned in Red Bluff dam lake when he attempted to swim from a raft to shore. The lake is near Odessa, Texas.

DR. GUSTAV EGLOFF, Universal Oil Products Company, Chicago, Illinois, and chairman of the Scientific and Technical Committee of the International Petroleum Exposition, will address the annual meeting of the National Petroleum Association to be held in Atlantic City, New Jersey, September 17 on the subject, "National Defense Chemicals from Petroleum." An address will be made September 18 by Lord Marley, deputy speaker of the House of Lords and formerly undersecretary of state for war of Great Britain. His discussion will cover regulation of business and labor relations in Great Britain.

ERNEST C. ARNOLD is new oil and gas inspector for the Osage Indian Agency. He assumed his duties September 1, having transferred from the Geological Survey to the Bureau of Indian Affairs.

FRED H. HAGGERSON was elected a director of Union Carbide and Carbon Corporation at a recent meeting of the directors held in New York. He is vice-president of the corporation, president of the Union Carbide Company, and president of the companies in the Electro-Metallurgical group. Haggerson has been with the corporation more than 20 years.

COL. W. F. ROCKWELL

COLONEL W. F. ROCKWELL, president of the the Pittsburgh Equitable Meter Company, Pittsburgh, Pennsylvania, has been appointed a National Councillor of the Chamber of Commerce of the United States to represent the Association of Gas Appliance and Equipment Manufacturers.

E. E. SPICER has become sales representative for Bradford Motor Works in the State of Kansas. Spicer was formerly with Frick-Reid Supply Corporation as manager of company stores at Russell and McPherson, Kansas, and Ada, Oklahoma. Recently he has been associated with the Buda Engine Company.

5,515 FEET

2,000 feet beyond rated capacity .....

Charles E. Hipp of Graham, Texas, recently finished deepening Continental Oil Company's No. 1 on the Ross Lease in Wichita County from 5,470′ to 5,515′ with a Bucyrus-Erie 36-L spudder. While we do not recommend use of the 36-L at depths so far beyond its rated capacity, nevertheless the performance record on this well proves beyond question this machine has ample reserve strength and power for handling drilling and servicing to the 3,500′ formations for which the machine was designed.

Says Mr. Hipp about the performance, "The 36-L handled this work with the same ease and efficiency that I have experienced on 4,000′ wells. It had ample power at all times. We had to splice 1,000′ of 7/8″ cable to the 5,000′ on the bull reel, so you may see there was considerable weight (x) in cable to handle in addition to the 2,500 lbs. of tools. We also ran a 4″ liner in this well and 5,500′ of 2″ upset tubing over our calf reel with three lines."

Can you use a 36-L on your operations? Please get your order in as promptly as possible because, though we are working our big factories day and night, it is hard to keep up with our defense orders and the requirements of our oil, mine, and construction customers.

(x) Total weight tools and cable — 9,250 lbs.

BULL REEL-6,900′ OF 7/8″ LINE

SAND REEL-AVERAGE 1,000 F.P.M.

CALF REEL-47 TON ON 6-PART

Bucyrus·Erie

SOUTH MILWAUKEE, WISCONSIN

CURTIS L. WILSON

CURTIS L. WILSON, who has been connected with the Montana School of Mines at Butte, Montana, for the last 20 years, and the last 13 years as professor of metallurgy and head of the metallurgy department, has been appointed Dean of the Missouri School of Mines and Metallurgy at Rolla, Missouri. Dr. Wilson succeeds Dr. William R. Chedsey, resigned.

Dr. Wilson is a member of the American Institute of Mining and Metallurgical Engineers, The American Chemical Society, and the Montana Society of Engineers. He is the author of numerous articles in the technical press and a book dealing with the metallurgy of copper is expected to be off the press in the near future.

JOHN N. SHUFFLER, engineer, Ingersoll-Rand Company, has been transferred from 11 Broadway, New York, New York, to 117 West Chippewa, Buffalo, New York.

J. C. HUNTER, Abilene, Texas, president of the Mid-Continent Oil and Gas Association, who formerly served as the personal representative of the governor of Texas on the Interstate Oil Compact Commission, has been asked to continue in that capacity by Governor Coke Stevenson. Hunter had been appointed by former Governor O'Daniel.

ROBERT E. ALLEN is now in the office of Petroleum Coördinator HAROLD L. ICKES, Washington, D. C., as Director of Production. Allen was formerly chairman of the Petroleum and Natural Gas Conservation Board of Alberta, Canada.

ROBERT E. ALLEN

HAROLD G. SMITH, former chief engineer of the automotive division of the Buda Company, Harvey, Illinois, has been promoted to executive engineer of Buda in charge of all engineering of automotive, marine, industrial, and radial Diesel engines. The announcement was made by R. K. MANGAN, executive vice-president. Well-known in the engineering field, Smith is a member of the S. A. E. and S. A. M. E.

F. A. WARTERFIELD, JR., chief engineer of the Oklahoma Pipe Line Company, has been transferred to the Plantation Pipe Line Company, where he is now vice-president. O. C. NONWEILER, southern division engineer of the Carter Oil Company at Shreveport, Louisiana, succeeds Warterfield. MYRON A. WRIGHT of Seminole, Oklahoma, succeeds Nonweiler and CARL G. HARRINGTON, eastern division senior petroleum engineer at Mattoon, Illinois, goes to Seminole as division engineer.

RUSSELL N. KEPPEL has been named president of the Standard Oil Company of Pennsylvania. Elected directors of the company are G. E. BUBAR and H. W. CHAPIN.

W. B. MARSHALL, formerly assistant sales manager of the conveying and engineering products division of the Chain Belt Company, Milwaukee, Wisconsin, has been made sales manager of that division. B. E. SIVYER, formerly San Francisco, California, branch manager, is now in Milwaukee as assistant sales manager of the chain belt and transmission division. S. Y. WARNER will replace Sivyer as branch manager at San Francisco.

ELMER W. PEHRSON was recently appointed chief of the Economics and Statistics Branch, U. S. Bureau of Mines. The appointment was announced by Dr. R. R. Sayers, director of the Bureau, who also stated that the Bureau's economics and statistics activities will be greatly expanded to meet the increased needs of the defense agencies and to fill a long-recognized need for additional statistical data on the mineral industries.

Pehrson, who is a mining engineer and economist, has been serving as active head of the economics and statistics branch since the retirement of James W. Furness in May, 1940. He is a member of the Interdepartmental Committee on Strategic Materials, and the Army and Navy Munitions Board Committee on Strategic Materials, Specifications and Storage, and is secretary of the Minerals Advisory Committee to the Army and Navy Munitions Board.

JOHN MORSE, son of Colonel Robert H. Morse, president of Fairbanks, Morse and Company, was killed in an automobile collision on the approach of the Golden Gate Bridge, San Francisco, California, August 22. Young Morse had been assistant manager of the company's San Francisco branch since last April, when he resigned from the navy because of an eye deficiency.

JOHN MORSE

A. V. HOENIG, vice-president in charge of oil production for the Indian Territory Illuminating Oil Company, recently absorbed by Cities Service Oil Company, has resigned, according to a statement by H. R. Straight, president of the latter company. Hoenig's resignation, which became effective September 1, had been considered for some time to permit him to devote his entire time to personal properties.

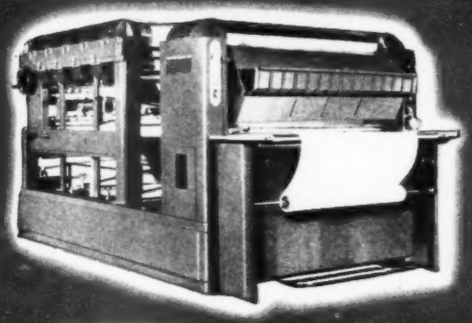
PARKER L. MELVIN, president of the Towne-Melvin Oil Company, the Pennsylvania Grade Crude Oil Association, and a member of the Independent Petroleum Association of America, has been appointed by GOVERNOR JAMES of Pennsylvania to represent that state on the Interstate Oil Compact Commission. Melvin has served as official observer on the Compact Commission for the State of Pennsylvania.

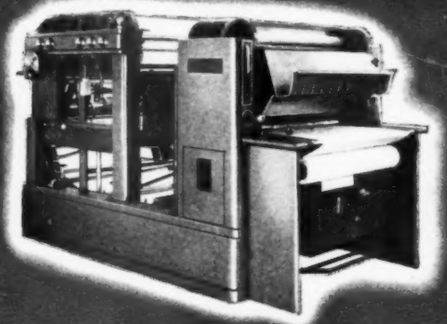
WRIGHT W. GARY was recently appointed Director of Refining in the office of the Petroleum Coördinator for National Defense, Washington, D. C. He has been assistant to the vice-president of the M. W. Kellogg Company for the last six years.

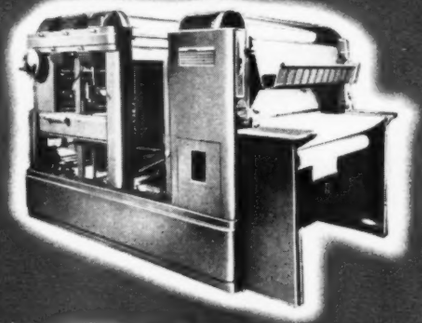
(Universal Press Photo Service)

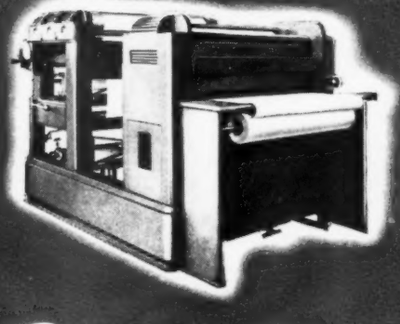
WRIGHT W. GARY

Are your BLUEPRINTS flat-contrasty-uniform?









THE CORRECT ANSWER IS "YES" WHEN YOU USE PEASE CONTINUOUS BLUEPRINTING MACHINES . . . . . they outsell all other makes combined!

MODEL "22"... finest and fastest of the streamlined family of continuous blueprinting machines, has Sliding Contact (gives 24¾ inches of uninterrupted "vacuum-like" exposure area); Three Speed Lamp Control (operating speed remains the same while lamp amperage can be changed to accommodate variable tracings); Actinic "No-Break" Arc Lamps (give unequalled uniform light); Horizontal Water Wash (eliminates bleeding and avoids wrinkles); Quick Change Chemical Applicator System (from Blueprints to Negatives in 30 seconds); and nine 8" diameter Aluminum Drying Drums (makes prints "flat as hung wallpaper"). Actual production speed in excess of 28 feet per minute. Made in 42" and 54" sizes.

MODEL "22-16"... combination of the "22" Printer and the "16" Washing and Drying Machines, has Sliding Contact, Three Speed Lamp Control, Actinic "No-Break" Arc Lamps, Horizontal Water Wash, Quick Change Chemical Applicator System, and five 8" diameter Aluminum Drying Drums. Actual production speed 20 feet per minute. Made in 42" and 54" sizes.

MODEL "16"... has Sliding Contact, One Speed Arc Lamps, Horizontal Water Wash, Quick Change Chemical Applicator System, and five 8" diameter Aluminum Drying Drums. Actual production speed 20 feet per minute. Made in 42" and 54" sizes.

MODEL "12"... smallest of the continuous streamliners, has Sliding Contact, One Speed Arc Lamps, Horizontal Water Wash, Quick Change Chemical Applicator System, and five 6" diameter Aluminum Drying Drums. Actual production speed 12 feet per minute. Made in 42" size only.

Descriptive literature on Pease Blueprinting Equipment will be sent upon request; merely indicate machine in which you are primarily interested. No obligation.

THE C. F. PEASE COMPANY
2613 WEST IRVING PARK ROAD
CHICAGO • ILLINOIS

Pease Blueprinting Machines

A TYPE AND SIZE FOR EVERY REQUIREMENT INCLUDING DIRECT PROCESS PRINTING

MACHINERY and EQUIPMENT

O.K. Rod Catcher

A NEW catcher for use in sucker rod strings, which is said to catch the string within 3 to 6 in. when a break occurs, is being marketed by the O. K. Tool Company, P. O. Box 54, Huntington Park, California. The quick action of this rod catcher is obtained through the application of a new principle that makes the setting of the slips independent of the falling of the rod string.

The O. K. Rod Catcher consists of a mandrel upon which are mounted the slip expander cone, the slip assembly, slip assembly balancing spring, and a heavy, square, helical operating spring. The upper end of the mandrel is equipped with a sucker rod coupling, and the lower part is encased in and attached to the body, which also supplies a pin connection for attaching the rod catcher in the string.

The rod catcher is made up at any desired point in the rod string. While being run into and out of the hole, and at all times during pumping, the weight of the rods below the catcher keeps the slip assembly retracted and the other parts in their proper positions. The balancing spring prevents the slips from being expanded during running-in and pumping.

When a break occurs in the rods, the tension in the rod catcher is released and the square spring instantly expands, drawing the slip expander downward between the slips. This spreads the slips outward into engagement with the wall of the tubing where they catch and hold the pump and all rods below the break. This action is effective in catching the rod string within from 3 to 6 in., it is stated.

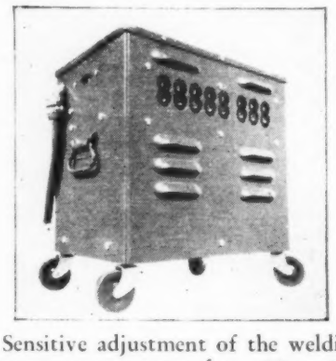
The slip area provided is extra large to prevent damage to the tubing, and the cross-sectional area of fluid passage through the catcher is greater than the area of the passage through the pump valves and seat. No rod guide is required except when the catcher is being used in a combination tubing string. The tool is keyed to prevent relative rotation of the parts, thus permitting backed-off rods to be made-up in the usual way.

An illustrated bulletin has been issued describing the O. K. Rod Catcher, which will be sent upon request by O. K. Tool Company.

Midget Marvel Flexarc Welder WT-1

FOR use in welding light gauge metal, castings and driveshafts, general maintenance, and light production work, a new Flexarc welder is announced by Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

Known as the Midget Marvel WT-1, this a-c. welder comes complete with all accessories, even to the primary cable for hooking-up the power line. Included in the accessories are electrode lead and holder, work lead, helmet, and a supply of electrodes.



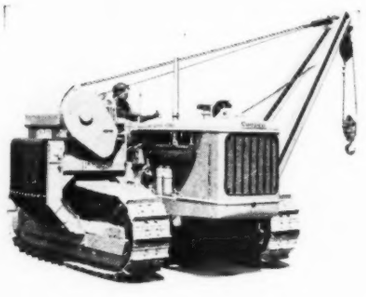
Sensitive adjustment of the welding current over a range from 20 to 140 amp. is provided by 15 steps with correctly proportioned increments between steps. Full load rating is 110 amp., 30 minutes, 30 load volts, when used on 220-volt, 60-cycle lines. The cost of power consumption averages about 5 cents an hour depending on local power rate.

The unit is very compact. Approximate dimensions are 14½ by 12⅛ by 20 in. long. Weighing only 160 lb., the welder is supported on casters to facilitate mobility.

Trackson's MD6 Pipe-Layer

TRACKSON COMPANY announces a new Model MD6 Pipe-Layer, a tractor side-crane that mounts on the new "Caterpillar" D6 model and takes full advantage of the increased power, ease of control, and other improvements built into this latest "Caterpillar" tractor.

The new MD6 Pipe-Layer has a lifting capacity ranging from 7300 lb. at 12 ft. overhang, to 23,700 lb. at 4 ft. overhang, and is one of a complete line of Trackson Pipe-Layers available with lifting capacities to 67,000 lb.



These husky, job-proved tractor side-cranes provide ample power, speed, and traction for the strenuous service of cross-country pipe-line construction, it is stated. They lift, lower, carry, and bend pipe, have super-high lifting capacities in proportion to their weight, can carry their loads anywhere at tractor speeds, and can operate easily in cramped quarters, the manufacturer asserts. Equipped with the Trackson "Anglefiller," the same machine will bulldoze, backfill, level, and spread.

Compact and agile, these machines do many other jobs well, in addition to their principal functions of cross-country pipe-laying, being equally useful around refineries, tank farms, etc., for all sorts of heavy lifting and lugging work.

The newly announced MD6 Trackson Pipe-Layer is shown here. Bulletin 459, available from Trackson Company, Milwaukee, Wisconsin, or from "Caterpillar" dealers, presents complete details.

STOP NEEDLESS LINER COST

NEW *Overall* TESTING METHOD INSURES 100% HARDNESS UNIFORMITY IN Mac CLATCHIE "MONEY-SAVERS"!

A new testing method, specially developed for the new improved "Money-Savers," covers the *entire inner bore* and reveals any soft spots that would cause premature breakdown. With this fool-proof hardness test, you get longer service life than ever before from every MacClatchie Liner you use!

IF YOU HAVEN'T INSTALLED A SET FOR THE LAST SIX MONTHS
***.. Switch Now* TO THE NEW, IMPROVED "MONEY-SAVERS"**

OTHER REASONS WHY THE *New Improved* MACCLATCHIE LINERS ARE REAL "MONEY SAVERS"

"Money-Savers" Are Quickly Replaced. The wear-free gland can be instantly slipped off the worn liner and placed on the new one, effecting important savings because you buy *only the liner itself* when renewing "Money-Savers." Saves *both* replacement and shipping costs.

"Money-Savers" Are Light in Weight. The patented process by which they're made produces a tough, long-wearing liner with uniform wall thickness on *all* sizes—both master and reduced — thus greatly lowering liner weight and saving shipping costs. On large foreign shipments, savings of several hundred dollars have been made this way.

"Money-Savers" Give Longer Life. Actual field tests have shown that these liners consistently out-wear costlier makes. "Money-Savers" have no soft spots to wash out or pit —a feature the new testing method proves on *every* liner. Result . . . Greater operating economy at lower unit cost.

For savings you can count in dollars and cents, make sure you specify new improved "Money-Savers" on your next liner installation. Available direct from factory — or from your nearest supply house — in all popular sizes for any make of pump.

There are More MacClatchie Liners Used Than Any Other Make — Quality is Responsible!

MacCLATCHIE MANUFACTURING COMPANY

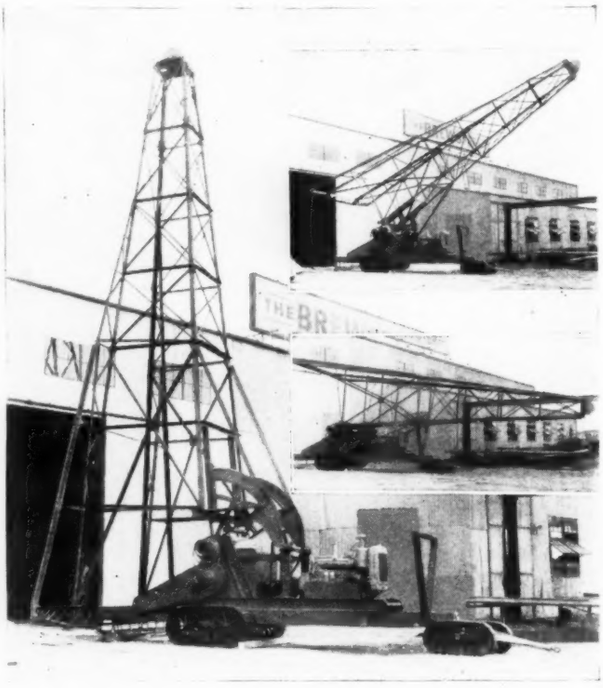
COMPTON, CALIFORNIA

Mid-Continent Distributor: HAKE TOOL COMPANY, Houston, Texas · Rocky Mountain Representative: MOUNTAIN SALES AND SERVICE CO., Casper Wyoming · Foreign: GEORGE R. WOODS, 17 Battery Place, New York City

Brewster's New Complete Light Rig

MOBILITY and ease of transportation were first and foremost in the minds of the engineers when they designed the Brewster Model FP-60-W Portable Rig, now in production by the Brewster Company, Inc., of Shreveport, Louisiana.

The 45½-ft. derrick of the Model FP-60-W is completely galvanized, and is raised as a single unit complete with crown block, by the large quadrant gear and small pinion drive. The worm reducer used on the quadrant drive serves as locking devices for the derrick at all times. The front opening of the derrick is 32½ ft. high. Removable all-welded side braces strengthen both front legs and add stability to the entire derrick. The raising mechanism serves as rear brace for the derrick. With these braces guy wires are unnecessary. The base of the derrick is 10 ft. square, thus allowing an unusually large floor for drilling operations.



A transmission with four speeds forward and one reverse gives the engine exceptional flexibility.

The drawworks drum is of the floating type, mounted on a live drumshaft and driven through a Twin-Disc friction clutch mounted between drum and bearing supports.

Rotary drive is through another Twin-Disc friction clutch mounted on the other end of the live drumshaft.

For more complete information and specifications write or phone the Brewster Company, Inc., Shreveport, La.

Metal-Clad Switchgear

METAL-CLAD switchgear specially designed for locations where the gear may be subject to corrosive and hazardous atmosphere is announced by the General Electric Company, Schenectady, New York. This vertical-lift-type switchgear is available in ratings to and including 15,000 volts with breaker ratings as high as 500,000 kva. to control incoming lines, feeders, and motors. The equipment is for either indoor or outdoor installation.

The new equipment has all the advantages of G-E standard metal-clad switchgear in general industrial service, plus a number of special features to meet the requirements of the industry, it is stated.

Its removable front and rear panels are fitted against a neoprene-covered felt gasket retained in a protecting channel. The gasket combines the compression qualities of felt with the gas-resisting qualities of neoprene.

Junctions between floor plate, side sheets, and top cover are sealed with compound retained in built-in channels. Construction of the complete housing is as an individual unit, facilitating addition of circuit units.

The secondary control devices are mounted within each enclosure in a separate explosion-proof box. This consists of a heavy, reinforced cast box sealed to insure complete protection of the operating equipment.

The oil circuit breaker in the equipment can be raised or lowered to the connected or disconnected position without opening the front door. A window in the door allows the operator to determine visually the position of the circuit breaker. An interlocking arrangement prevents lowering or raising a closed circuit breaker.

External surfaces of the equipment have a special corrosion-resistant finish and the inner surface of the roof and side sheets are lined with pulverized cork to prevent troublesome condensation.

Self-Orienting Full-Gauge Deflecting Tool

A NEW TYPE of full-gauge deflecting tool, which is self-orienting and is run into the hole without the use of orienting clamps or surveying instruments, is being marketed by the Eastman Oil Well Surveying Company of Dallas, Texas, and Long Beach, California. Known as the Driftmaster, the new tool is used for hole straightening, controlled directional drilling, and sidetracking cement plugs. Features asserted for the Driftmaster are that it automatically orients itself on the bottom to the low side of the hole and can be pointed to drill in any desired direction. The only survey operation necessary before running the Driftmaster is that a drift indicator or a single-shot reading be taken. The tool is then run on the drill pipe in the same manner as running the ordinary bit. The use of orienting equipment is not required, nor does the hole have to be ratholed or reamed, it is stated.

The Driftmaster embodies some of the features of the well-known knuckle joint type of deflecting tool and includes in addition the self-orienting mechanism, which, through eliminating the need for orientation while running-in and subsequent checking with surveying instruments, saves time and avoids drilling delays, according to the manufacturer.

Arc-Welder Control Box

FURTHER improvement in Dual Continuous Control for arc-welding machines, in the form of a new welder control box of advanced design and construction, is announced by The

Lincoln Electric Company, Cleveland, Ohio.

Enhancing the benefits of Dual Continuous Control, the new box, designated "Type G", (see accompanying illustration), prevents accidental contact with live parts, increases accessibility, permits wiring with flexible or rigid conduit, or rubber-covered multiple-conductor cable, and eliminates dangers from unintentional loosening of the lifting hook, it is stated.

An important feature of the new box is the fact that there is a separate compartment for all a-c. circuits, including push button, and another separate one for d-c. terminals.

Both a-c. and d-c. compartments have a snap catch that holds the door in closed position. The a-c. compartment door also has screws for locking to prevent any unauthorized person from opening the compartment and touching live parts. The catch, however, holds the door in closed position in case the screws should accidentally or temporarily be left out of their proper places. On the d-c. compartment, the snap catch feature of the door makes the terminals readily accessible without the use of tools and, at the same time, provides a complete cover for the terminals when the door is closed.

Another important feature of the "Type G" control box is the improved design and construction of the lifting hook.

The hook is made of round stock, bent to the form of a loop, arc-welded to the sub-panel of the control box on one end and looped over a cap screw on the other. The cap screw is fastened into an angle piece, which is arc-welded to the frame.

Special non-shorting lugs, which lock themselves in proper position before they can be bolted to the input terminals of the starter, prevent the possibility of blowing up the input lines due to shorted input lugs because of careless maintenance.

The control box is permanently grounded to the motor and generator frames through the mounting bolts to take care of special inspection rules that require that both the control box and the frame should be grounded. This feature makes it possible to ground both the control box and the machine by simply grounding the conduit that leads to the box.

Heat Resisting Qualities of Standard V-Belts Increased

STANDARD construction V-belts in the past have been recommended by The B. F. Goodrich Company only for operations in temperatures of less than 130°F. Specially compounded heat-resisting V-belts were supplied for temperatures greater than 130°F.

The company now announces that as a result of development and research it has been able to increase the heat-resisting qualities of its standard V-belts so that they are now fully equal to the special black heat-resisting belts.

For this reason the special black heat-resisting construction is discontinued, and the standard belts can be ordered from stock for drives on which the heat-resisting belts have previously been necessary.

You Can't Miss—when you **Pick "CLEVELANDS"**

CHECK THESE FEATURES:

1. Speed and fast maneuverability.
2. Dependable, tested full-crawler traction.
3. Wide tread and low ground pressure.
4. Multi-speed transmissions.
5. All enclosed gears.
6. Quick-shift conveyor.
7. Double-strength (carbon manganese) steel in frame, boom and ditcher-buckets.
8. Quick — accessible Unit-Type Construction.
9. Box-type ditcher boom.
10. Long life, low maintenance assured and the dead-weight eliminated by super quality material.

•

The above are only a few reasons why more and more people are picking "Clevelands"... Complete information is yours for the asking

THE MODEL 140 PIPELINE DITCHER. Digs 18 to 30 inches wide, 5' 4" deep

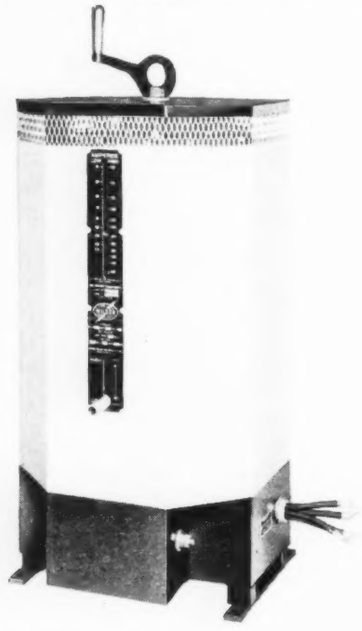
THE MODEL 90
One man operated continuous travel backfiller. Handles pipe, too.

THE CLEVELAND TRENCHER COMPANY
Pioneer of the Small Trencher
20100 ST. CLAIR AVENUE CLEVELAND, OHIO

Wilson Transformer Arc Welders

A NEW line of a-c. transformer welders in 300-, 500-, 750-, and 1000-amp. capacities has been announced by Wilson Welder and Metals Company, Inc., New York.

Known as Model TW, these welders are completely self-contained units. They are designed for 220-, 440-, or 550-volts, 25- or 60-cycle current. When arranged for 220- and 440-volt operation, single phase, either voltage



can be brought into use by a reconnection of the leads, which are brought outside the unit.

The new welders have a wide range of current output and continuous stepless current regulation is provided over the entire range by means of a hand crank on top of the machine. This crank makes it possible to rapidly shift the setting as changes are made from one class of work to another.

The Model TW conforms to N.E.M.A. requirements, and is said by the manufacturer to operate coolly, because of divided construction of the coils, which allows greater surface area to be exposed to the cooling air. All coil covering is spun glass fiber, heat-resistant, Class BB insulation, providing trouble-free operation even if used continuously at maximum settings.

On 60-cycle units, all sizes are fan cooled except the 300-amp. size, which is cooled by natural draft. On 25-cycle units, all sizes are fan cooled. The 60-cycle units have high and low range switches, whereas the 25-cycle units have only one range. This low range switch provides current adjustments on the 500-amp. size from 40- to 650-amp. Power factor correction is included in all models for 60-cycle operation except the 300-amp. size. Welders built for 25-cycle operation do not have power factor corrected. Efficiency of all the TW units is approximately 80 to 85 percent.

Valve Positioner

A NEW valve positioner for diaphragm-operated valves has been developed that provides for the optional use of a bypass valve that is made as an interchangeable part of the unit. Emphasis has been made in the design to provide a sturdy construction, similar to that of the valve with which it is used, to meet the actual operating requirements. The heavy calibrated loading spring, in addition to operating the pilot bellows, always acts in the same direction to take up any back lash in the lever connections. Adjustments for valve strokes of from ½ in. to 2½ in. and for setting zero are readily accessible and may be made without interrupting the control process. By turning the bypass from "positioner" to "instrument" the positioner may also be completely removed without upsetting the service.

The design, it is stated, has been made so that a linear relationship always exists between the instrument air pressure and the actual motion of the valve. The bellows and stainless steel pilot are a self-contained unit, made without levers that might introduce friction and cause hysteresis error.

Tests have shown a sensitivity of 1/5 of 1 percent for full scale instrument pressure change. Speed of operation has been found to be approximately 11 seconds for full travel on an average 1-in. stroke valve. Air consumption is less than 1 cu. ft. of free air per min. at mid-stroke, and zero at either end of the valve travel as the pilot is closed at both limits.

The equipment is manufactured by Moore Products Company, 3629 North Lawrence Street, Philadelphia, Pennsylvania.

Aerodynamic Impellers for Pumps

THE interdependence of apparently widely divergent branches of engineering is illustrated by the successful use of aerodynamic data in the field of hydraulics. Engineers of the Peerless Pump Company at Los Angeles every day are demonstrating that in many respects water flow is analogous to air flow. This fact led to changes in the design of propellers for large capacity low head pumps used in drainage and dewatering operations.

The reduction of turbulence and internal friction in a pump handling as much as 100,000 gal. per min. is a highly important consideration in power economy. Exhaustive studies of the data developed in wind tunnel research have resulted in modifications of propeller blade contour, area, and angular set. Pumps equipped with modified propellers and discharge columns with improved vane arrangement show distinct advantages when tested in the laboratory under conditions identical with those in field service, it is stated.

Ingersoll-Rand Impact Wrench

INGERSOLL-RAND COMPANY announces the Size 534, a new and improved, air-operated impact wrench for use in applying and removing nuts up to 1¼-in. bolt size. It is designed with the patented Pott Impact Wrench principle that localizes the steel-to-

The Size 534 Impact Wrench running-up cap screw

steel impact without transmitting shock to other parts of the tool. Reversing gears are not used. A small nose diameter and short overall length permit operation in close places. Smooth, balanced power with negligible torque reaction makes possible safe and convenient one-hand operation. This tool is ideal for use in shipyards, oil refineries, chemical plants, steel construction, and general repair shops, the manufacturer asserts.

A new illustrated booklet, Form 2758, gives many interesting particulars of this new wrench. The complete line of five sizes for applying and removing nuts from ¼ to 1¾ in. bolt sizes is also illustrated and described. Copies can be obtained from Ingersoll-Rand Company, 11 Broadway, New York, or any of their branch offices.

Now...

GRAY Catalytic Desulfurization*

ELIMINATES MERCAPTAN SULFUR

also

SUBSTANTIALLY REDUCES NON-MERCAPTAN SULFUR AT LOW COST

and thereby

MARKEDLY INCREASES LEAD RESPONSE

and

SAVES SWEETENING COSTS

▪ ▪ ▪

APPLICABLE TO A WIDE VARIETY OF HIGH SULFUR GASOLINES AND TO MANY LOW SULFUR GASOLINES

▪ ▪ ▪

A REFINER, who recently started operating Gray Catalytic Desulfurization commercially on low sulfur straight-run gasolines from Illinois crudes, reports these results:

(1) An unleaded octane increase of close to 3 units by the A. S. T. M. Motor Method.

(2) An octane increase of 6.5 units with 3 cc of Tetra Ethyl Lead.

(3) Complete mercaptan sulfur elimination.

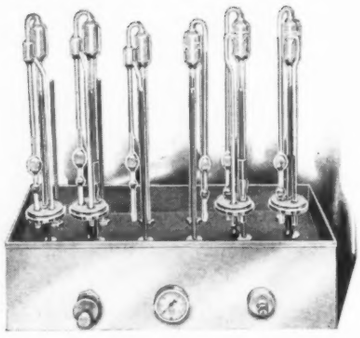
(4) 75% reduction in non-mercaptan sulfur.

Licensed by

THE GRAY PROCESSES CORPORATION

26 JOURNAL SQUARE • • JERSEY CITY, NEW JERSEY

Tag-A.S.T.M. Kinematic Viscosity Cleaning Apparatus



THE cleaning and drying apparatus shown herewith primarily was designed for glass viscosimeters for determining kinematic viscosity; however, it is also adaptable for use in connection with the cleaning of other types of glassware such as test tubes, pipettes, etc.

The tubes are placed over and supported by vertically extended metal capillary tubes through which the cleaning fluid is sprayed.

Drying is accomplished by passing air under pressure through the tubes. Pressure is regulated by means of special valves and the amount of pressure may be closely controlled and observed. Provision is made for first connecting the spray line to the vessel containing the cleaning liquid. Then by adjusting the valves, air is forced through the tubes. To prevent excessive use of solvent or cleaning fluid, a spring type valve is used that closes when the valve handle is released.

The equipment is manufactured by C. J. Tagliabue Manufacturing Company, Brooklyn, New York.

Keeping the Wheels Going

with

DEPENDABLE

and

ECONOMICAL

Electric Power

★ ★ ★ ★ ★

Oil Fields

National Defense

Industries

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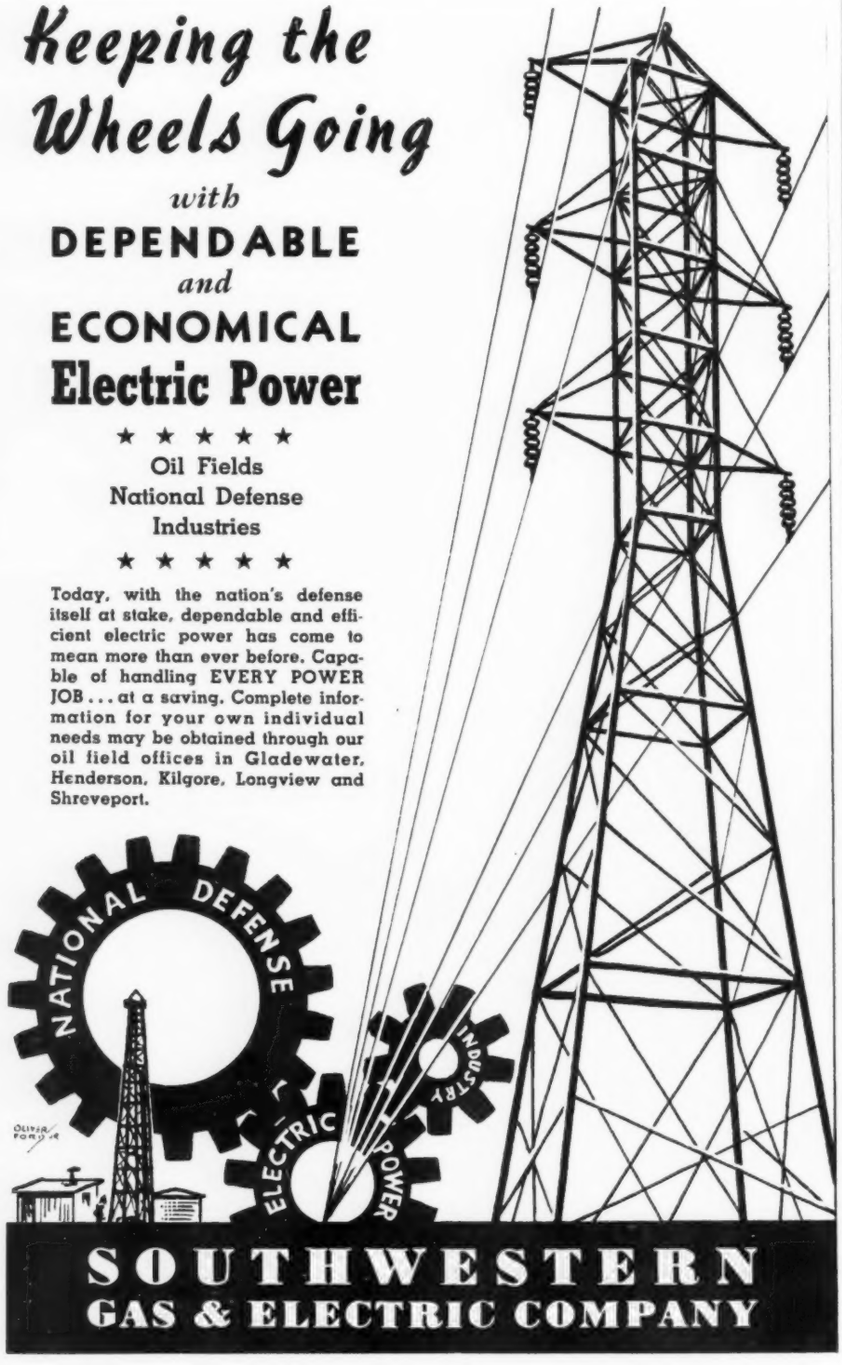
Today, with the nation's defense itself at stake, dependable and efficient electric power has come to mean more than ever before. Capable of handling EVERY POWER JOB . . . at a saving. Complete information for your own individual needs may be obtained through our oil field offices in Gladewater, Henderson, Kilgore, Longview and Shreveport.

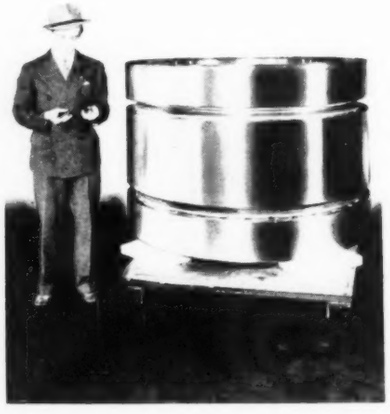


SOUTHWESTERN

GAS & ELECTRIC COMPANY

Large Capacity Bearings Installed in Aluminum Mill

FOUR Timken tapered roller bearings, manufactured by The Timken Roller Bearing Company, Canton, Ohio, installed on the back-up rolls of the new, 4-hi, reversing hot mill of Aluminum Company of America mill at Alcoa, Tennessee, have 30 percent more capacity than any bearings previously built, according to a statement of the manufacturer.



Harley Allison, Timken Production Department employee, compares smallest Timken tapered roller bearing with the largest one ever built.

These bearings have a 35½-in. bore by 51-in. O.D. by 36-in. width. They weigh 9070 lb. each and have a mill separating force capacity of 8,300,000 lb. at mill speed.

Each bearing is a four cage assembly with 34 machine turned, case carburized rolls per cage, or a total of 136 rolls per bearing. Individual rolls are 4 in. in diameter, 7¼ in. long, and weigh 23.37 lb.

The cones and cups are forged. The cages are turned.

Lane-Wells Appoints Sales Managers

Jas. D. Hughes and J. C. Barcklow have been appointed sales managers for the Gulf Coast and Mid-Continent divisions of Lane-Wells Company, according to an announcement by M. E. Montrose, Lane-Wells vice-president and general sales manager. These men will direct the company's sales engineering work in the divisions named.

JAS. D. HUGHES

Hughes, whose headquarters are at Houston, attended Texas A. and M. and Oklahoma University before joining the engineering department of the Humble Oil and Refining Company in 1924. From there he went to Venezuela for four years with the Lago Petroleum Company working on drilling and production practices and production research. For two years after returning to the States he did special work on production analysis and lifting cost studies for Southern Crude Oil Purchasing Company, which was later absorbed by Stanolind Oil and Gas Company. In 1934 Hughes joined Eastman Oil Well Surveying Company of Texas. He resigned as vice-president of that company and organized Oil Well Engineering Company to manufacture and distribute specialized drilling equipment. He disposed of his interests in this company and joined the Lane-Wells organization in Houston in 1939.

J. C. BARCKLOW

Jack C. Barcklow will make his headquarters the Mid-Continent Division offices at Oklahoma City. Barcklow is a graduate of Penn State in mining geology and first worked for the Midwest Refining Company in Wyoming. He later joined the geological department of Carter Oil Company and subsequently went with the Skelly Oil Company as district geologist at Ardmore, Oklahoma. Later he joined the Deep Rock Oil Corporation and supervised that company's drilling operations as to stratigraphy, casing points, interpretation of electrical logs, perforation, and drilling-in procedure. Barcklow joined Lane-Wells in Oklahoma in 1940.

Again... GRIZZLY HELPS DRILL 'EM DEEP

Honolulu Oil Corporation Well No. 25-P, Buena Vista Hills, California

Grizzly Pressure Seal Rotary Hose again demonstrated its ability to withstand the hard service and high pressures encountered in record breaking deep wells by successfully contributing to the completion of Honolulu's P-25—World's deepest electrically drilled well—14,622 feet total depth.

Grizzly's superior performance is your protection against hose troubles, leaks, repairs, replacements and excessive hose costs. Ask your supply dealer or write direct for Bulletin No. 20-OF.

E. M. SMITH COMPANY
600-650 South Clarence St., Los Angeles, California, U. S. A.
Complete Stocks Maintained in Our Warehouses At:
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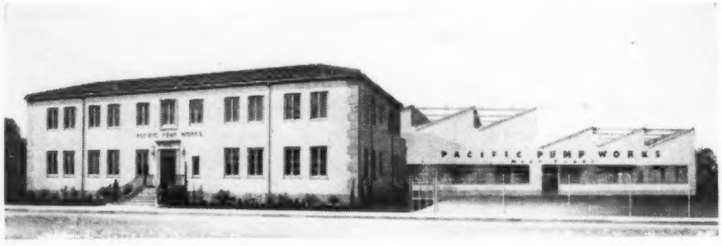
Export Office:
Continental Emsco Co., 30 Rockefeller Plaza, New York City
Distributed by Leading Supply Companies.

GRIZZLY
PRESSURE-SEAL ROTARY HOSE

Clark Opens New West Coast Office

J. B. O'Connor, vice-president of Clark Bros. Company, Inc., Olean, New York, announces the opening of a new West Coast office, which will be in charge of A. K. Hegeman.

Clark Bros. Company, for the last ten years, has been represented on the West Coast by the Smith-Booth-Usher Company of Los Angeles.



The new sales office and warehouse will be at the plant of the Pacific Pump Works, Bicket Street and Slauson Avenue, Huntington Park, California.

Art Rowe will be in charge of the service department and a complete stock of repairs will be carried, it is announced.

It's Testing Time

It's testing time for industry . . . testing time for men, machines and management. Sustained, high-speed production is demanding specialists of proved skill . . . machines of demonstrated efficiency . . . organizations of recognized ability.

That's why manufacturers and users of all types of industrial machinery entrust their clutch problems to the Twin Disc Clutch Company's 23 years of specialized experience in building clutches *to fit the job . . . not merely to fit the machines of which they are a part.* Why not submit your clutch problem to Twin Disc engineers? Twin Disc Clutch Company, 1329 Racine Street, Racine, Wisconsin.

Illustrated: Left, *Twin Disc Power Take-off.* Right, *Twin Disc Model E Heavy-duty Clutch.*

This single point adjustment is an exclusive feature in ALL Twin Disc Clutches. Easy and quick . . . no special tools needed. Simply pull up the pin, rotate collar to next hole and release the pin.

"Double E" Succeeds Kibele

R. A. Wilson of Dallas, Texas, announces the acquisition of all assets of the Kibele Manufacturing Company and the organization of Equipment Engineers, Inc., to succeed the Kibele Manufacturing Company.

The well and favorably known Kibele swabs, packers, tubing catchers, etc., in the future will be marketed under the trade name of "Double E" as will also such new items of oilfield equipment as may be developed from time to time by the new company.

R. A. WILSON

Wilson has been president of the Kibele company for a number of years. He is well known in the oil industry for a large number of inventions and improvements in oilfield equipment and has been active in the affairs of the Rotary Drilling Equipment Committee of the A.P.I. for many years.

Wilson announces the appointment of J. M. Shimer as vice-president and A. P. Brown as secretary and treasurer of Equipment Engineers, Inc. Until May 1, 1941, Shimer was vice-president of the Oil Well Supply Company in charge of engineering, having served in that capacity since the merger of Oil Well and the Wilson-Snyder Manufacturing Company in 1929. Prior to that time he was vice-president of Wilson-Snyder in charge of engineering and manufacturing, having begun as general superintendent in 1920. He is the patentee of a large number of improvements in oilfield equipment and has been active in A.P.I. work as chairman of the Manufacturers Sub-Com-

J. M. SHIMER

A. P. BROWN

mittee for Rotary Drilling Equipment during the last six years.

Brown has been connected with the Kibele Manufacturing Company for four years. He has been in the accounting field for the last 12 years since his graduation from Southern Methodist University in 1929.

No change is contemplated in the method of distributing "Double E" products through oilfield supply companies throughout the oil industry. Field engineers thoroughly experienced in the production of oil and "Double E" equipment will continue to function as in the past.

Equipment Engineers, Inc., will maintain its engineering and manufacturing headquarters at Dallas, Texas.

Agencies Merge

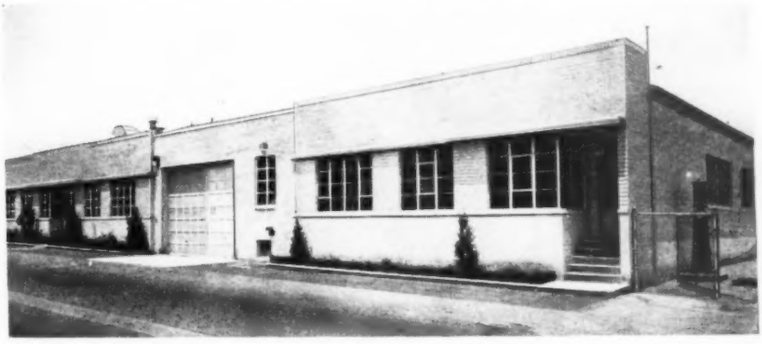
Brooks-Wilson Advertising is the name given to the merged firms of Wilson Advertising Agency and Leslie Brooks and Associates. The new firm is at 410 McBirney Building, Tulsa, Oklahoma. As a result of the merger, a nationally recognized advertising agency with a larger, experienced staff is offered their customers.

American Recording Acquires Anubis Laboratories

The American Recording Chart Company, manufacturers of "Arcco" recording charts and for several years distributors of Anubis instruments, has recently acquired the entire business of the Anubis Laboratories of the late Geo. Sydney Binckley. In May, 1940, the growth of their chart business necessitated the erection by the American Recording Chart Company of their own building at 3113 East 11th Street, Los Angeles, California. To provide precise control over the manufacture of recording charts the building was air conditioned throughout. An engraving room was provided in which are cut the wax engravings used to make the copper plates from which all "Arcco" charts are printed. Storage space for several car loads of special chart paper, a stock room for more than 1,000,000 charts, a battery of especially equipped printing presses, and modern office facilities complete the modern building.

The acquisition of the Anubis Laboratories necessitated the enlargement of the present building to include the new laboratory and instrument shop.

American Recording Chart Company is also the exclusive distributor for the well known Macnick Chart Clock. A recent addition to their line was shown for the first time at the Appalachian Gas Measurement Short Course at the University of West Virginia, August 18, 19 and 20, 1941. This was the new Arcco-Macnick differential unit. This unit offers for the first time a differential recording device using no mercury and is adaptable for use in conjunction with several types of present orifice meter equipment, it is stated by the makers.



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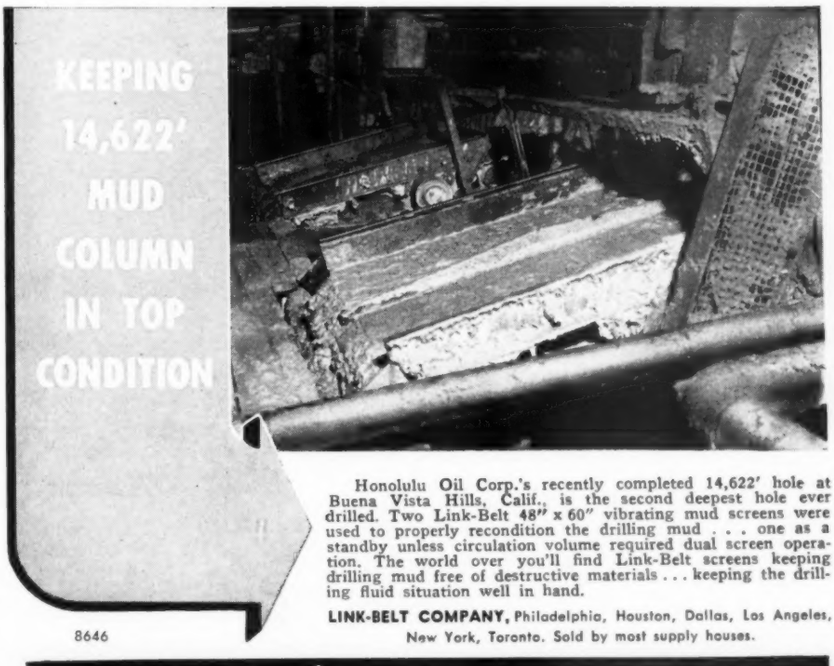


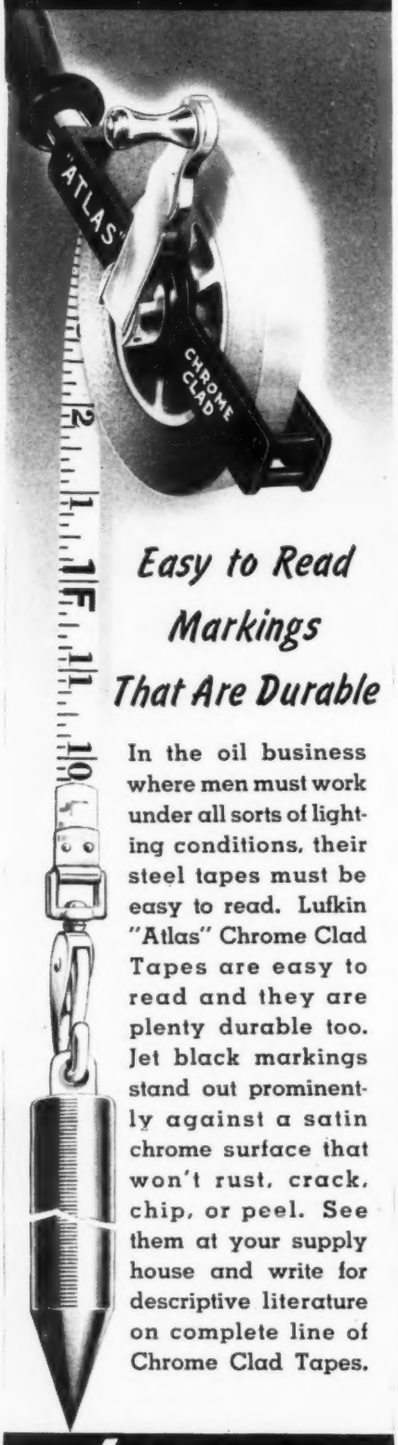
Honolulu Oil Corp.'s recently completed 14,622' hole at Buena Vista Hills, Calif., is the second deepest hole ever drilled. Two Link-Belt 48" x 60" vibrating mud screens were used to properly recondition the drilling mud . . . one as a standby unless circulation volume required dual screen operation. The world over you'll find Link-Belt screens keeping drilling mud free of destructive materials . . . keeping the drilling fluid situation well in hand.

LINK-BELT COMPANY, Philadelphia, Houston, Dallas, Los Angeles, New York, Toronto. Sold by most supply houses.

8646

LINK-BELT MUD SCREEN

"ATLAS"
CHROME CLAD
STEEL TAPES



Easy to Read Markings That Are Durable

In the oil business where men must work under all sorts of lighting conditions, their steel tapes must be easy to read. Lufkin "Atlas" Chrome Clad Tapes are easy to read and they are plenty durable too. Jet black markings stand out prominently against a satin chrome surface that won't rust, crack, chip, or peel. See them at your supply house and write for descriptive literature on complete line of Chrome Clad Tapes.

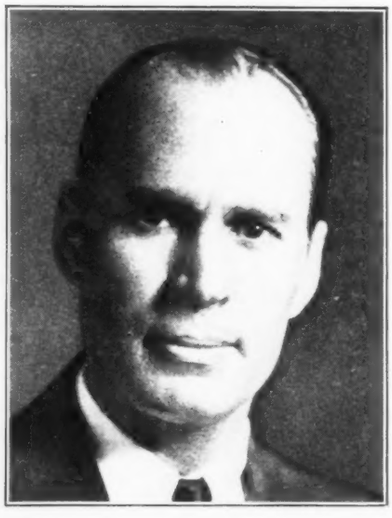
LUFKIN
SAGINAW, MICHIGAN · New York City
TAPES · RULES · PRECISION TOOLS

Pittsburgh-National Representatives Meet

A series of meetings was recently held at various district offices of the Pittsburgh Equitable Meter Company, attended by salesmen from both the parent concern and those of its National Meter Division. At these meetings the two sales forces were consolidated into a single working group. Each representative now handles, in his territory, the sales and service for the entire Pittsburgh-National line of meters. Factory engineers and executives led the discussions at these meetings. During recent months many members of the sales force have also visited the company plants in Pittsburgh and Brooklyn.

Top row: N. W. Simcoe, Clyde Hum, George Bender, A. H. Wille, Dan Gannon. Center row: H. D. Leisenring, Harry H. Clark, R. P. Parshall, W. J. Klevorn, D. G. Kappelman, Paul Payton. Bottom row: Ross Burns, Fred Hartmann, W. F. Rockwell, Captain A. E. Higgins, P. C. Kreuch, W. N. Calkins

Ideco Appoints a New Vice-President



C. R. ATHY

C. R. Athy has been named a vice-president of International Derrick and Equipment Company of Ohio. Athy has been affiliated with the Ideco organization since the early days of its history, having been chief engineer the last ten years. During this time he was also in charge of research work and has developed many items of oilfield equipment now in common use. He is active in A.P.I. standardization work and is chairman of the Manufacturers' Sub-Committee on Rigs and Derricks.

Athy was graduated from the Ohio State University in 1919 as a chemical engineer. Before joining Ideco, he was associated with the Buckeye Steel Castings Company and the American Zinc Lead and Smelting Company.

In his new capacity Athy is relinquishing his duties of chief engineer to L. E. Roelofs. Roelofs was formerly associated with the American Bridge Company and, also, was general manager of the Rogers Structural Steel Company of Corry, Pennsylvania.

W. C. Thomas Resigns From Magnolia

W. C. Thomas has resigned his position as district superintendent of Magnolia Petroleum Company's Lake Charles, Louisiana, district after serving in this capacity since the Magnolia-Vacuum merger in 1932. He plans entering business for himself after an extended vacation.

W. C. THOMAS

Thomas is a veteran in the industry, having passed his 20-year service period with the Standard Oil Group April 26 of this year. He began his oil industry career at Spindletop in 1901 as a helper with Brick and Bradley, which later was the Burt Syndicate until the latter was taken over by the old Magnolia Refining Company.

In his 40 years in the industry, Thomas has worked in every branch, beginning with a job on the laying of the first pipe line from the present Magnolia refinery at Magpetco, near Beaumont, to Sabine Pass. Prior to the Magnolia-Vacuum merger he was general superintendent of drilling and production for Vacuum Oil Company, with headquarters in Houston.

Atlas Coordinates Engineering and Machinery Service

To obtain better coördination between field stores and the general offices on matters of engineering and machinery sales and service, Bruce E. Gold, chief engineer of the Atlas Supply Company, has transferred his headquarters from the Tulsa, Oklahoma, office to Muskogee, Oklahoma, headquarters.

BRUCE E. GOLD

Gold joined Atlas organization in March, 1937, with headquarters at the Tulsa office, from which he covered all field stores of the company in the interest of machinery sales. Prior to joining the Atlas staff, he spent 12 years with Weber Engine Company, Kansas City, Missouri, serving as assistant chief engineer from 1930 to 1936. He was also with Caterpillar Tractor Company, Peoria, Illinois, spending six months in the service department before going to Tulsa.

Stop Costly Air Leaks

with

LUNKENHEIMER

AIR CONTROL DEVICES

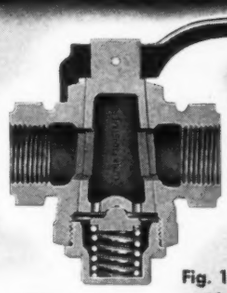
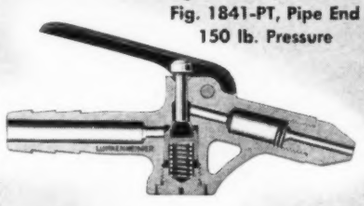


Fig. 1571 Air Cock
150 lb. Pressure

Air Nozzles
Non-Metallic Disc
Fig. 1840-PT, Hose End
Fig. 1841-PT, Pipe End
150 lb. Pressure



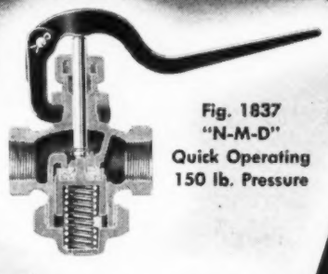


Fig. 1837
"N-M-D"
Quick Operating
150 lb. Pressure

Are you losing money because of leaks in your compressed air lines? Even a tiny leak the size of a pin hole may be stealing some of your profits—losses which can easily amount to a substantial sum at the end of a year.

You can stop these costly leaks with Lunkenheimer Air Control Devices. Included in the line are air cocks, air nozzles, globe, check and quick operating valves, and pop safety valves. They are a sure way to end air wastage and they'll pay their cost many times over in the savings they make.

For full information on the complete line of Lunkenheimer Air Devices send for copy of Catalog 78.

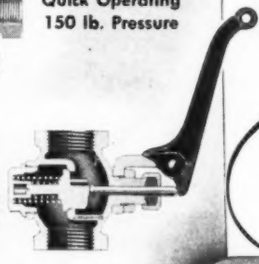


Fig. 635
Regrinding
Quick Operating
200 lb. Pressure

ESTABLISHED 1862
THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO
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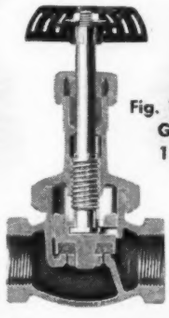

Fig. 123, "N-M-D"
Globe Valve
150 lb. S. P.

Pop Safety Valves
for Air
Fig. 1226, Top Outlet
5 to 250 lb. Pressure

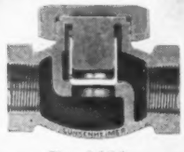

Fig. 1616
Air Compressor Check Valve
200 lb. Pressure

Buy from your local Lunkenheimer distributor! He is cooperating in every way to give you the kind of service you so vitally need for the National Defense Program.

A STANDARD CHOICE

Ludlow Double-Disc Gate Valves employ the famous principle of gate and wedge construction which Ludlow developed and perfected. Valves embodying this type of construction are particularly suited to motor operation. All danger of jammed gates is eliminated because the wedges release with a minimum amount of energy. This principle also allows free operation throughout the full length of the gate travel, lessening motor wear and power consumption.

Ludlow Valves can be furnished in all standard sizes and types or specially made to your specifications. Write for catalog and prices or we shall gladly recommend and quote on valves for special purposes.

LUDLOW PRINCIPLE

Self-releasing 30° angle wedges and flexible action gates self-adjusting to seats for improved performance, longer life.

Part of a recent shipment of Ludlow Valves for a larger refinery operation.

The LUDLOW VALVE MFG·CO·INC· SINCE 1866 TROY·N·Y·

Traveling Exhibit of Hamer Products

Hamer Oil Tool Company recently put on the road a traveling exhibit of all Hamer products for a tour of the oil areas of the United States, a program that will require the remainder of 1941 and which will cover more than 50,000 miles. An especially finished heavy-duty truck exhibits Hamer products under actual working conditions, which are operated by a pressure system equivalent to 8000 lb. cold water pressure—conditions more severe than those actually encountered in the field or refinery.

L. S. Hamer, president, is shown on the exhibit and Ernest Dunn, engineer for the company, in the rear as the exhibit prepared to leave Long Beach, California, for the tour. Dunn is in charge of this traveling exhibit, which is designed to roll up to headquarter office, field warehouse, drilling rig, or refinery for a working demonstration. The exhibit reached the Texas Gulf Coast early in July. It will go next into Louisiana, Arkansas, Oklahoma, Kansas, the Illinois Basin, and on to the East Coast refinery district before turning west.

C. T. Hapgood Transferred To Houston

C. T. HAPGOOD

The appointment of C. T. Hapgood as assistant district sales manager at Houston, Texas, for the Jones and Laughlin Steel Corporation has been announced. He formerly held the same position at Los Angeles, California.

Effective at the same time, W. R. K. Scott was transferred from the Jones and Laughlin Houston office to the Los Angeles office.

Correction

Attention of the reader is called to errors that appeared in the article entitled "High-Pressure Acidization of Cores," by P. G. Shelley, J. B. Stone, and L. W. Colburn, published in the 1941 Annual Number of *The Petroleum Engineer*.

On page 60 in the third column beginning in line 14 the sentence beginning with "Analysis" should read as follows: "Analysis shows the Niagaran to be almsot pure dolomite and the other rocks to be almost pure limestone."

On page 67 in the middle column beginning in line 16 the text should read as follows: "than the atmospheric-pressure treatments. If in Table I, only tests wherein the original permeability was between 100 and 300 millidarcys are considered, the average acidizing index drops to 8.64 at atmospheric pressure."

The phrase in parentheses on page 68, column 1, line 17, should read as follows: ("and that which was *not* dissolved was compressed to small volume").

REGARDLESS

of water or operating conditions, type of boiler or method of firing, SAND-BANUM will safely and economically remove old and prevent new scale and corrosion.

"The Entirely Different Boiler and Engine Treatment"

REGARDLESS

of age, climatic conditions or how stored, SAND-BANUM does NOT deteriorate!

PROVE it to your SATISFACTION At Our Risk

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9 Rockefeller Plaza
New York City

Stocks carried by
WESTERN SAND-BANUM COMPANY
Houston, Texas Fresno, California
and at other convenient points including leading supply houses

•

Export Representatives
PETROLEUM MACHINERY CORP.
30 Rockefeller Plaza New York City

University of Texas Gets Petroleum Engineering Building

One of three new buildings under construction on the University of Texas campus is a three-story, $200,000 Petroleum Engineering Building.

The building covers more than 33,000 sq. ft. of floor space.

A special feature of the building will be its huge "display room," where the petroleum engineer's heavy field and refinery equipment will be swung up for study by means of overhead track carriages.

The new building will be ready for occupancy this fall.

Also going up on the Texas campus are a Music Building and a Chemical Engineering Building.

Dealers Appointed for Acme Wall Cleaning Scratchers

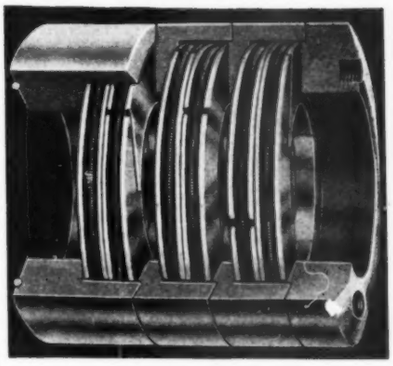
The 75 stores of the Frick-Reid Supply Corporation and the nine stores of the Petroleum Equipment Company on the west coast have been appointed exclusive distributors in their respective territories for Acme Wall Cleaning Scratchers, according to the Weatherford Spring Company, Weatherford, Texas, manufacturer of the device.

Acme Wall Cleaning Scratchers are used to remove the cake of mud and cuttings from the wall of the hole when cementing casing or running slotted or perforated liner. By anchoring these scratchers around the casing or liner at intervals they serve also to center the casing in the well.

The manfacturer states that cement flows more evenly around the pipe because of the centering action of the scratchers. The cement also bonds firmly with the walls of the hole because mud and cuttings have been cleaned away, leaving the formation exposed to the cement, it is asserted.

Liner centered with Acme Scratchers is kept from direct contact with the producing formation, and production is further encouraged by removing the filter cake, restoring normal capillary attraction.

Acme Scratchers are said by the makers to be exceptionally satisfactory because the oil tempered bristles do not strip from the device, even in the deepest holes under the most unfavorable conditions. The bristles are anchored by a preformed pivot spring at the base of each, fully protected. The scratchers rotate and reverse without harm to the bristles, except for normal wear on the ends, for which ample provision is made.



IN PACKING PERFORMANCE

Specify France "Full-floating" Metal Packing for reciprocating piston rods as well as reciprocating or oscillating valve stems and obtain sealing efficiency of the first rank. There is a proven France design for any type of engine, pump or compressor.

Promotes top level production
Prevents costly shutdowns
Protects product uniformity

Call on *experienced* France Engineers for detailed, technical information. Write for Catalog M-3.

THE FRANCE PACKING COMPANY
Tacony Philadelphia Penna.

Mid-Continent Representative:
Mr. J. M. FULLER, 2603 Azle Avenue
FORT WORTH, TEXAS

Original **FRANCE METAL PACKING**

New Headquarters for Waukesha Completed

Waukesha Motor Company, Waukesha, Wisconsin, celebrated the completion of the Los Angeles branch's new headquarters on September 12 with an open house and Dutch luncheon. Hosts were Herbert Wirshing, district manager and head of the Waukesha staff in Los Angeles; Harley Winn, in charge of field service; seven others on the branch staff; Wendell Jones, Jack Graves, and Pete Irwin of Petroleum Equipment Company; Roy Wright, W. C. Durant, and A. Miller of Frazier-Wright Company.

Waukesha Motor Company's new Los Angeles branch

The new Waukesha branch building, at 4927 Pacific Boulevard, is a 73-ft. by 106-ft. concrete and steel fireproof structure with a saw-tooth roof on a 105-ft. by 250-ft. lot. A side door is provided for truck delivery of small parts, as well as a rear door for trucks to back into the building under a 3-ton traveling crane that facilitates the loading and unloading of heavy machinery.

PRE-FORMED with *Plus* Features—

UNION-FORMED WIRE ROPE

Union-Formed wire rope has plus features because it is rigidly supervised throughout — from the raw material specifications through the manufacturing. In addition, to extra durability and economy typical of all Union ropes, Union-Formed ropes meet pre-formed specifications and then *plus* each *pre-formed* feature with Union's top quality.

UNION WIRE ROPE CORPORATION
GENERAL OFFICES AND FACTORY:
2106 Manchester Ave. Kansas City, Missouri
Tulsa • Houston • Chicago • Salt Lake City
New Orleans • Monahans • Portland • Ashland, Ky.

UNION Wire Ropes

The "ULTIMATE LOW COST WIRE ROPE"

Chaplin-Fulton Represented by Blanchard Smith

The Chaplin-Fulton Manufacturing Company of Pittsburgh, Pennsylvania, announces that Chaplin-Fulton Regulators will be represented in the Mid-Continent territory by Blanchard Smith, who formerly represented the Reynolds Gas Regulator Company. Smith was also for years connected with Westcott and Greis, Inc., of Tulsa, Oklahoma, and is well known to users of gas equipment. His territory, including Iowa and Nebraska on the north and Louisiana and Texas on the south, will comprise eight states, with headquarters in Kansas City, Missouri.

BLANCHARD SMITH

The George Gudes On Vacation

George E. Gude, Jr., sales manager, Wyatt Metal and Boiler Works, left Houston, Texas, September 6, accompanied by Mrs. Gude, for an automobile vacation in the Rocky Mountain territory. They are golfing and loafing, mainly, at Colorado Springs, but Yellowstone is the goal of the jaunt. Port of first call was Decatur, Arkansas, where George plowed raspberries at 75 cents per daylight tour upon arrival as a Dutch boy immigrant before he discovered America had engineering schools and oil.

Eric G. Schroeder with Lucey Products

Eric G. Schroeder, for many years a partner and sales manager of the Kibele Manufacturing Company of Dallas, Texas, has resigned from the company and disposed of his interest in it to become associated with Franklin E. Bernsen in the Lucey Products Corporation of Tulsa, Oklahoma.

ERIC G. SCHROEDER

Schroeder has been actively engaged with the Lucey organization since the first of the year and will continue his offices in the Continental Building at Dallas. He is vice-president and a director of the Lucey Products Corporation, in charge of Texas operations.

Schroeder, a graduate of the University of Missouri, went to Texas in 1920 and has continued to reside in the state since that time. He has been actively identified with the oil equipment industry since 1928, first at San Antonio and then at Dallas, to which city he moved in 1935.

Schroeder is well known in Mid-Continent and California oil circles. He is secretary-treasurer of the Dallas Petroleum Club.

A. K. Hegeman Represents Clark on West Coast

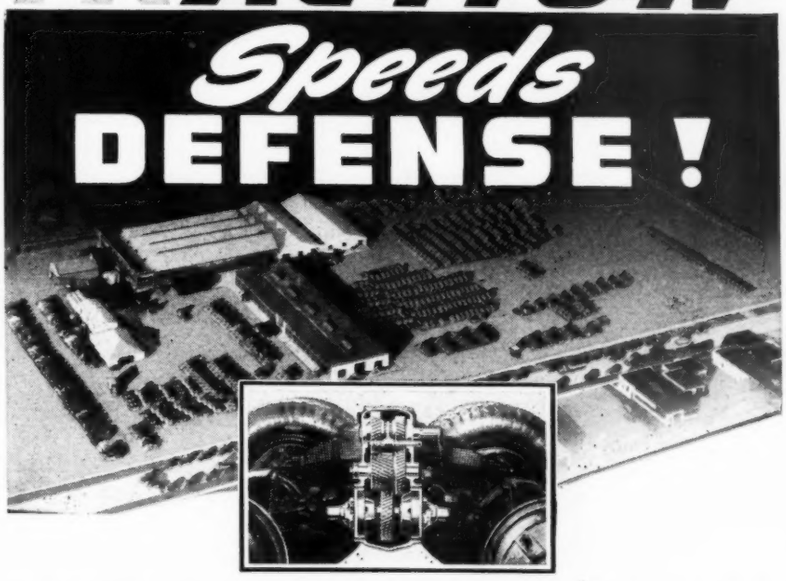
A. K. HEGEMAN

Clark Bros. Co., Inc., of Olean, New York, manufacturers of gas and Diesel engines and engine-driven compressors, have announced a change in address of their Pacific Coast office and warehouse and the appointment of A. K. Hegeman as West Coast manager.

Hegeman is a graduate of the University of California College of Mining Engineering. After his graduation he served in the World War as a lieutenant in the U. S. Field Artillery. At the close of the war he engaged in mining engineering work in Utah until 1923, when he became sales manager for the Cochise Rock Drill Company of Los Angeles. The following year he entered the employ of the Smith-Booth-Usher Company of Los Angeles, where he has since been engaged in oil-field sales work. The Smith-Booth-Usher Company has been Clark's Pacific Coast representative for the last ten years, and Hegeman has had wide experience in selling, installing, and servicing Clark engines and compressors.

Clark's new sales office and warehouse are at the plant of the Pacific Pump Works, Bicket Street and Slauson Avenue, Huntington Park, California. A service department is maintained, carrying a complete stock of repair parts, with Art Rowe in charge.

TRACTION Speeds DEFENSE!



THORNTON FOUR REAR WHEEL DRIVE

Today the eyes of the world are on America!

The prestige of our nation depends on the speed and effectiveness of our Defense program.

In these vital times not only our moral and physical fiber must meet the test, but we must measure up in sheer ability to handle the jobs assigned to us.

Tough assignments are nothing new for THORNTON four rear wheel DRIVE. For years they have helped solve transportation problems both on and off the highway. They have proven their worth in meeting stiff requirements where loads are heavy and the going is rough!

It is not surprising to find thousands of THORNTON-equipped trucks in the thick of the struggle. They are actually on the fighting front in many parts of the world. Right here at home they are doing their bit not only in military vehicles but for the all-important job behind the lines in the construction of army, navy and airplane bases, highways, factories and the transportation of vital supplies.

THORNTON TANDEM CO.
8733-8779 GRINNELL AVE. DETROIT, MICH.
Manufacturers also of the THORNTON automatic-locking DIFFERENTIAL
"When you need TRACTION you need THORNTON"

C. L. Hogan, President Lone Star Cement, Passes Away

Charles Louis Hogan, president and general manager of the Lone Star Cement Corporation, and one of the leaders of the Portland cement industry, died in New Rochelle Hospital September 5, in his 61st year.

Hogan, whose home was in Mt. Vernon, New York, leaves a widow, Mrs. Margaret Groves Hogan, and a daughter, Mrs. Robert R. Booth, of Mt. Vernon.

Hogan, who had served as president of the Lone Star Cement Corporation since November, 1933, was born in Tippecanoe City, Ohio, October 3, 1880. He moved to Kansas City as a boy, and after completing his education, entered the railroad business, with which he was identified until 1910, at which time he was commercial agent for the Chicago, Great Western Railroad Company at Kansas City.

After severing his connection with the Chicago, Great Western Railroad, Hogan entered the cement business as traffic manger of the Lumbermen's Portland Cement Company, of which he became secretary and sales manager. In 1914 he became identified with the Altoona Cement Company, Altoona, Kansas, as president and manager, continuing in that capacity until 1921.

Hogan became associated with the Lone Star Cement Corporation in 1921 as manager of the Cuban Portland Cement Company, Havana, Cuba, a Lone Star subsidiary. In 1924 he became vice-president and manager of Lone Star's New York subsidiary, then the Knickerbocker Portland Cement Company, Albany, New York. In 1926 he was elected vice-president of the Lone Star Cement Corporation, and in 1928 became senior vice-president. In November, 1933, Hogan was elected president and general manager.

At the time of his death, he was a member of the board of directors of the Portland Cement Association, having previously been the chairman of that board. He was also a member of the board of directors of the Manufacturers Trust Company of New York.

Halliburton to Render Gravel-Packing Service to Oil Industry

Texaco Development Corporation announces the closing of a license agreement with Halliburton Oil Well Cementing Company whereby Halliburton will be prepared to conduct gravel-packing operations for the oil industry in accordance with the latest procedure developed by The Texas Company.

Gravel-packing has been successfully employed in California, Texas, and Louisiana for the prevention of sand trouble in oil wells, and Texaco Development Corporation owns various patents and inventions covering this procedure, including those of Leslie A. Layne of Houston, Texas, and Professor Lester C. Uren of the University of California, Berkeley.

In connection with this arrangement and with the expectation that gravel-packing will be largely used in the future, Texaco has substantially reduced the royalty charges, it is announced.

WANTED: Young graduate engineer as assistant to refinery engineer. Two to four years' refining experience including drafting, refinery construction and maintenance. Location, southwest. Submit complete details of qualifications, salary desired, photograph, etc. Address Box C, care The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

N.G.A.A. Gas Testing Committee

Members of another technical research group of the Natural Gasoline Association of America, the Gas Testing Committee, have been announced by Ray E. Miller, Hanlon-Buchanan, Inc., president of the association.

H. L. Oder, Cities Service Oil Company, Bartlesville, Oklahoma, was named chairman of the group and S. M. McAnelly, Lone Star Gasoline Company, Ranger, Texas, was made vice-chairman. Other members of the committee are H. H. Beeson, Sabine Valley Gasoline Company, Inc., Shreveport, Louisiana; J. G. Burnham, Shell Oil Company, Inc., Tulsa, Oklahoma; P. M. Childers, Continental Oil Company, Ponca City, Oklahoma; D. L. Clark, Parade Gasoline Company, Inc., Overton. Texas; R. H. Clark, Phillips Petroleum Company, Bartlesville Oklahoma; Paul C. Coffin, The Shamrock Oil and Gas Corporation, Amarillo, Texas; D. L. Edmondson, Lisbon Gasoline Company, Inc., Henderson, Texas; J. S. Feroe, Hanlon-Buchanan, Inc., Tulsa; W. F. Fulton, United Gas Pipe Line Company, Shreveport; F. E. Huff, Standard Oil Company of California, San Francisco, California; Fred F. Ketchum, Owens, Libbey-Owens Gas Department. Charleston, West Virginia; A. C. Lankford, The Carter Oil Company, Tulsa; A. Lucas, Skelly Oil Company, Carter Nine, Oklahoma; H. E. Means, Coltexo Corporation, Monroe, Louisiana; John Middleton, Mid-Co Gasoline Company, Malakoff, Texas; E. M. Parkin, Glacier Production Company, Cut Bank, Montana; Clegg Perry, Warren Petroleum Corporation, Tulsa; Norman K. Rector, Glen Rose Gasoline Company, Tulsa, and C. H. Smith. Kansas Power and Light Company, McPherson, Kansas.

This committee has an unusually heavy work agenda this year, according to President Miller. Among the projects planned is one concerned with studies of high-pressure gases with a view to possible standardization on methods of testing and meaurement. A new method for determining the specific gravity of such gases is already under consideration and experiments are being made with several new methods for determining the activation of charcoal used in testing natural gas for its gasoline content.

Crane Co. Elects J. L. Holloway Vice-President

J. L. Holloway was elected a vice-president in charge of finance of Crane Co., Chicago, Illinois, at a meeting of the board of directors held on August 25.

Holloway joined the Crane organization in 1935, was elected secretary of the company in 1937 and, in addition, was appointed assistant to the president in 1940, which positions he held until his election as vice-president. Holloway interrupted his studies in engineering at the University of Manitoba to go to France with the Canadian forces during the last war; then entered the accounting field, becoming a chartered and certified public accountant, in which capacity he had an extensive experience covering practically every phase of operation in a great variety of corporations.

At the same meeting of the board, W. H. Winslow, Jr., was elected secretary. He joined the Crane organization in 1939 to handle tax and legal matters for the company, and has been assistant secretary since early in 1940. He was with the American Army in France during the last war, following which he resumed his study of law, was admitted to the bar, and practiced law as a member of well-known law firms.

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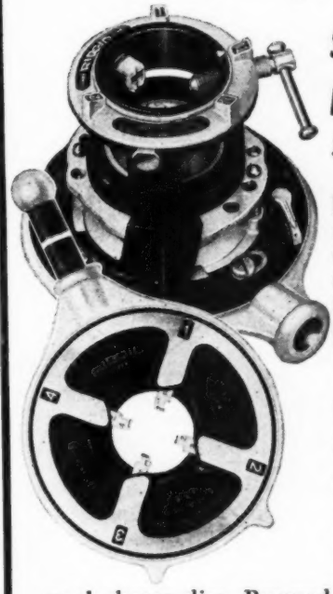
Speed Your Part of the Big Job with these Work-Saver

RIDGID

No. 65R Pipe Threaders



Set to thread 1" to 2" pipe by an easy 10-second adjustment

Beating schedules comes natural to the miracle of voluntary American skill. . . . These self-contained No. 65R RIDGIDs help you do *your* part. They set to thread 1", 1¼", 1½" or 2" pipe of any kind in one quick adjustment — no extra dies to carry around, lose or cause delay. Instant setting workholders, practically automatic — no bushings. Clean perfect threads from hi-speed steel chaser dies. Rugged all-steel and malleable-alloy construction. . . . Save vital time and work — ask your Supply House for these RIDGID 65Rs.

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RIDGID

WORK-SAVING PIPE TOOLS

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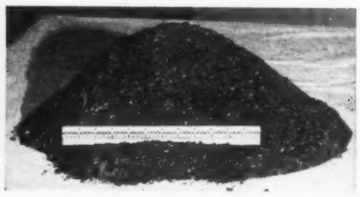

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BRIDGE PLUGS . . .

SLIPS . . . *or any other kind of material or junk,*

you are assured of a faster, easier job by using

CAVINS AUTOMATIC HYDRAULIC SUCTION BAILER

This time, trouble, and money-saving tool works like magic in well-cleaning operations. Get in touch now with any of our branches—listed below—and be prepared to fish the fast, easy Cavins way. Our staff of competent service men are always ready to give you prompt, dependable service. Illustrated Bulletin sent on request.

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Branches and Service Representatives Located at: Long Beach, Bakersfield, Ventura, Taft, Houston, Corpus Christi, Kilgore, Dallas, Lake Charles, Houma, Denver, Lance Creek, Ellinwood.

On Petroleum Coordinator's Staff

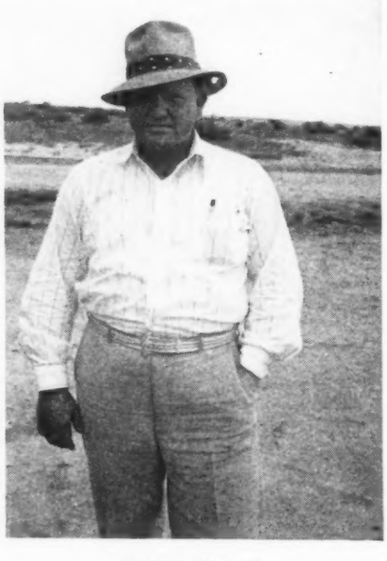
Stanley W. Crosthwait is an executive officer on the staff of Harold L. Ickes, Petroleum Coördinator. He is a government career man with a long

STANLEY W. CROSTHWAIT

record of service in the Department of Interior, during which time he has specialized in personnel work.

Joins Baash-Ross

Russ Williams has recently joined Baash-Ross Tool Company as fishing tool man in the West Texas and New Mexico area with headquarters at Odessa, Texas. At the present time, he



RUSS WILLIAMS

is living at Seagraves, Texas, serving the Slaughter and Wasson fields and other pools in this territory.

Prior to his new connection Williams was with Oil Well Drilling Company as toolpusher for nine years.

Williams is well known in South Louisiana, Oklahoma, California, and in West Texas and New Mexico.

Look for the *Arm and Hammer*

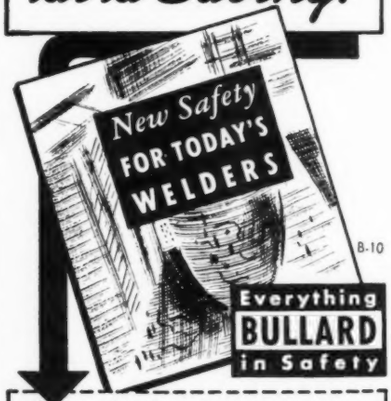
ARMSTRONG BROS.

STUB END WRENCHES

These extra heavy, ruggedly designed Chrome Vanadium Steel Wrenches take long tubular slip-over handles, stand up to long leverage . . . tighten screws, bolts and nuts far tighter or loosen them even when badly corroded. These are ideal wrenches around rigs, pipe lines and for general heavy duty work. Three types (from 1¼" to 3½") with long hollow tubular steel handles, each of which fits several sizes.

"The Tool Holder People"
331 N. Francisco Ave., Chicago, U. S. A.

LET THIS GUIDE HELP YOU SELECT REAL PROTECTION *at a Saving!*



Free booklet describes welder's protective equipment that meets today's specialized welding demands.

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NATIONWIDE SALES AND STOCKS

Book Reviews

Dangers and Health Hazards of Fire Gases, by Harold Joe Davis, 3927 East Admiral Place, Tulsa, Oklahoma. Price 25 cents.

This booklet was written to better familiarize those responsible for both industrial and public safety on the dangers and health hazards of fire gases. It explains which materials, chemicals, gases, etc., give off deadly fire gases while burning; what toxic gases each gives off, their effect on the human body; and safeguards for each.

Oxygen-Boosting of Diesel Engines for Take-Off, Bulletin 54, by P. H. Schweitzer and E. R. Klinge. Published by Pennsylvania State College Engineering Experiment Station, State College, Pennsylvania. Price, 50 cents; pages, 29.

A bulletin containing a complete report of an investigation concerning the injection of oxygen into the intake air of a Diesel engine for increased power output. Test data from the investigation reveal a power increase of 60 percent. Other important data are included in the bulletin.

Emulsions and Foams, by Sophia Berkman and Gustav Egloff. Published by Reinhold Publishing Corporation, 330 West Forty Second Street, New York, New York. Price, $8.50; pages, 591.

Incorporated in this publication is a complete explanation of the theory of emulsions and of foams. With the explanation of the theory are thorough explanations and data on emulsification and demulsification from the practical standpoint. Also included is practical information on asphalt and bitumen emulsions and lubricating-oil emulsions.

In five chapters, the last chapter of the book deals exclusively with laboratory methods used in the examination of emulsions. It includes the sampling of emulsions, sampling apparatus used in well gauging, test methods, emulsification and demulsification, investigation of the emulsifier, demulsifier, and determination of emulsion type and emulsion constituents.

Pumps and Pumping, by E. Molloy. Published by Chemical Publishing Company, Inc., Brooklyn, New York. Price, $2.00; pages, 104.

A practical manual on the operation, installation and maintenance of reciprocating, centrifugal, and rotary pumps. Information is also included on direct-acting and oscillating pumps. One section deals with suction and delivery heads, pipe friction and losses, and some useful formulae for calculating the capacity and efficiency of pumps. Discussions are given of well and borehole pumps, air-lift and submersible pumps, and pulsometer steam pumps.

Death Calls M. J. Tennes, Sr.

M. J. Tennes, Sr., chairman of the board of directors of the Shafer Bearing Corporation, Chicago, Illinois, passed away recently.

Tennes is survived by his widow, Ida B. Tennes; his daughter, Dorothy Tennes, and three sons, Captain Monte J. Tennes, Jr., president of the Shafer corporation, now on active duty in the United States Army Air Corps; Ray P. Tennes, secretary-treasurer and director of the Shafer corporation, and Ensign Horace E. Tennes, also a director of the Shafer corporation, now on active duty in the United States Navy Air Corps.

Tennes, Sr., who had served as chairman of the board of directors of the Shafer corporation since 1934, had a host of friends in the bearing industry. His charming personality and pleasant good fellowship shall long be remembered by those who have been privileged to know him.

HERE'S THE SPEED SET FOR RUSH JOBS

Machinery laid up for repairs is costly. To make quick, efficient repairs every plant needs this PLOMB Master Tool Set—one of a wide variety available. Composed of 114 tools and sturdy metal chest, the assortment consists of:

MIDGET SOCKETS—¼" Sq. Drive
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ALL WITH ATTACHMENTS

Also, open end and box wrenches, screw drivers, feeler gauge set, punches and chisels, etc. See this set at the friendly PLOMB jobber in your neighborhood or write us for FREE CATALOGUE.

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Rockford Clutches

At The TOP In Reliability and Economy

Rockford Clutches give tip-top results at low cost in oil field services. They are designed by long-experienced industrial clutch specialists, built by efficient modern methods. Their reliability, smooth operation and economy are proved daily on widely varied oil jobs in leading tractors, power units, and specialized production equipment driven by internal combustion engines.

Rockford Plate Clutches are made in two general types, illustrated, and many standard sizes. Over-Center type, above, locks in or out of engagement; has exclusive, easy-action roller cams. Spring-Loaded type, at left, works like an automobile clutch. Rockford Power Take-Offs fit S. A. E. flywheel housings, take any plate clutch. Specify Rockford Clutches for reliable power control.

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Over-Center, Spring-Loaded and Pullmore Clutches

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TRADE-MARK REGISTERED U.S. PAT. OFFICE

EASY OPERATING, FAST, EFFICIENT
STOCKS AND DIES
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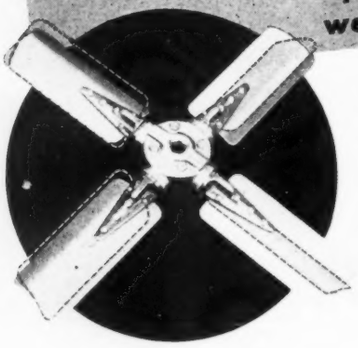
KONTROL-FAN
complete automatic temperature control
insures
UNIFORM ENGINE TEMPERATURE
regardless of weather or load



- Prevents oil sludging and dilution.
- Lengthens engine life and cuts maintenance costs.
- Insures constant, uniform cooling — no sudden inrush of cold water — less scaling.

Radiator temperature controls the thermostat to fade fan blades in or out of pitch automatically, holding engine temperature within desired range.

For complete information and prices, write
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TRADE LITERATURE

What to Write For

E. D. Bullard Company, 275 Eighth Street, San Francisco, California, offers their booklet describing welders' protective equipment that meets today's specialized welding demands.

Address The Chaplin-Fulton Manufacturing Company, 28-40 Penn Avenue, Pittsburgh, Pennsylvania, for Bulletin No. 130, also Catalog C-F covering all needs of pressure control.

Write for Free Catalog No. TG-4 from the Coffing Hoist Company, Danville, Illinois. Information, specifications, and prices are presented on the complete line of Coffing hoisting equipment.

Full information on the France "full-floating" metal packing for reciprocating piston rods and reciprocating or oscillating valve stems is contained in Catalog M-3 of The France Packing Company, Philadelphia, Pennsylvania.

Bulletin GEA-3595 has complete data on the General Electric Tri-Clad splash-proof motor for use in plants and on pumping units. Address General Electric Company, Schenectady, New York.

Descriptions of Le Roi Company, Milwaukee, Wisconsin, gasoline, natural gas, and butane drilling engines are in their bulletin DE4, giving complete information on 4-, 6-, 8-, and 12-cylinder engines.

Details of Lincoln "Shield-Arc" welding are given in Bulletin 412, available on request from The Lincoln Electric Company, Cleveland, Ohio.

For full information on the complete line of Lunkenheimer air control devices, send for a copy of their Catalog 78. Mail request to The Lunkenheimer Company, Cincinnati, Ohio.

Information on the use of "Karbate," carbon, or graphite materials used in the manufacture of pipe and fittings can be obtained on request by sending name and address to the National Carbon Company, Inc., 30 East 42nd Street, New York, New York.

Penberthy reflex gages are fully described in Catalog 34-A. Write addressing Penberthy Injector Company, Detroit, Michigan.

"Skinner offers a clamp for every leak" in their complete catalog mailed on request by addressing M. B. Skinner Company, South Bend, Indiana.

Interested persons are asked to request their nearest supply dealer or write direct for Bulletin No. 20-OF for information on the Grizzly Pressure-Seal rotary hose. Address E. M. Smith Company, 600-650 South Clarence Street, Los Angeles, California.

The helpful catalog and data book "Tube-Turns" containing information on welding fittings of all types, sizes, and weights will be sent on request by addressing Tube-Turns, Inc., Louisville, Kentucky.

NEW METHODS that are being successfully employed in speeding up defense construction, accelerating movements of military material, and simplifying general material handling in many industries with speed and economy are discussed in the new Traxcavator catalog offered by the Trackson Company, Milwaukee, Wisconsin.

THE HOMESTEAD VALVE MANUFACTURING COMPANY, INC., Corapolis, Pennsylvania, offers their catalog 17A-10 covering the new Hypressure Jenny Steam Cleaner.

COPIES WILL BE SUPPLIED to any official, department head, etc., who makes his request on a company letterhead, and indicates his position, of the Pease 156-page Catalog M-41 presenting a concise description of arc lamp continuous blueprinting, washing and drying equipment, and other equipment manufactured by the company. Address The C. F. Pease Company, 2601 Irving Park Road, Chicago, Illinois.

THE BROWN INSTRUMENT COMPANY, Philadelphia, Pennsylvania, has just issued a new catalog, No. 2204, entitled "Brown Mechanical Meters—Flow and Liquid Level." The catalog contains 16 pages of useful and valuable information written specifically to give the busy executive, plant engineer, and instrument man a complete description of Brown mechanical flow and liquid level meters for indicating, recording, and controlling. A copy of the catalog will be gladly sent to any readers who request it. Address The Brown Instrument Company, Wayne and Roberts Avenues, Philadelphia, Pennsylvania.

Floyd Swindell to Vapor Recovery Systems Staff

The Vapor Recovery Systems Company, Compton, California, announces the appointment of Floyd L. Swindell as Mid-Continent sales representative with headquarters at Tulsa, Oklahoma, according to Frank V. Long, president.

FLOYD L. SWINDELL

Swindell is a graduate of the University of Oklahoma, with post-graduate work at George Washington University. His first engagement was with the U. S. Bureau of Mines at Bartlesville, Oklahoma, where he was assistant petroleum engineer studying oil-field problems in connection with exploration, development, and production of oil and gas.

For four years he was employed by the United States Treasury Department in the income tax unit as valuation engineer. From 1930 to 1936 he was Kansas-Oklahoma editor and staff representative of the *Oil Weekly*. Since 1936, Swindell has been engaged largely as a consulting engineer and geologist, specializing in field geology work and income tax valuation. He was employed by the Texas Steel Company and Texasteel Manufacturing Company as sales engineer for oil-well equipment in Arkansas, Texas, Oklahoma, and Kansas. He was also connected with the Buda Engines Sales and Service as sales engineer selling oil-field power.

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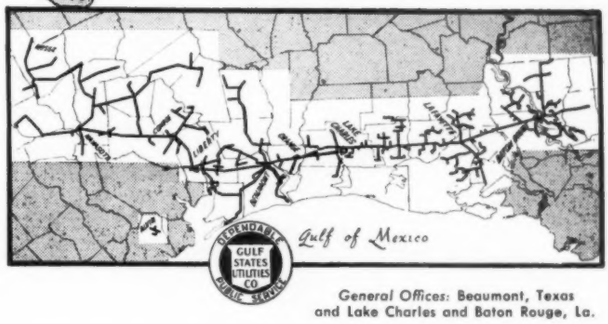

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For detailed **JENSEN JACK** *description and specifications, see . . .* **PRODUCING EQUIPMENT DIRECTORY** *or* **COMPOSITE CATALOG.**

EXPORT OFFICE: 50 CHURCH STREET, NEW YORK CITY

Plomb Tool Establishes Industrial Relations Department

Creation of an Industrial Relations Department with James Leslie Goddard as manager is announced by the Plomb Tool Company. The new department has been formed to meet the needs of rapid company growth as they relate to personnel plans and development, and public relations, it is stated.

J. L. GODDARD

Goddard is particularly well equipped for his new position. Admitted to the California State Bar in 1925, he practiced law in Los Angeles for four years, and for 12 years was secretary and general counsel of the Goodyear Tire and Rubber Company of California. In his capacity as manager of Plomb's Industrial Relations Department he will be in charge of personnel, public relations, and legal matters pertaining to the company.

Lane-Wells Export Office Now in Los Angeles

Effective September 1, 1941, all export business of the Lane-Wells Company formerly handled from New York is being conducted from the company's general offices, 5610 South Soto Street, Los Angeles, California, according to an announcement by M. E. Montrose, Lane-Wells vice-president and general sales manager.

Dresser Opens Houston Warehouse

On September 2, 1941, Dresser Manufacturing Company, Bradford, Pennsylvania, opened a new warehouse at Houston, Texas, to make available to the Southwest ready-made joints overnight for speedy laying of pipe lines. As the national emergency calls for speed and more speed in new drilling and in construction of oil lines, Dresser's Houston warehouse will save vital time by making it possible for users to draw on full stocks of Dresser products for immediate laying of lines, it is pointed out.

The new warehouse is at 1121 Rothwell Street, Houston, Texas, and is in charge of David H. Geiser, manager, an experienced Dresser man from the Southwest. C. T. Davis, district manager, Gas and Water Division, and H. R. Shidel, district manager, Oil-Field Division, will have their headquarters at the new district office now located at the warehouse address.

New Addresses for Foxboro Branches

The Foxboro Company, Foxboro, Massachusetts, announces a change of address for two of its branch offices. Yeatman Anderson and his associates in the Cincinnati, Ohio, office are now at 607 American Building, Walnut Street and Central Parkway.

E. B. Miller is now manager of the St. Louis, Missouri, branch office and R. H. Hemfelt is his assistant. New address of the company is the Continental Building, 3615 Olive Street. Miller is the possessor of an extensive and valuable background of experience with The Foxboro Company. He succeeds E. R. Huckman, who has been transferred to the New York, New York, territory.

C. H. Kennedy Called by Death

Clarence H. Kennedy, 51, died at St. Joseph Hospital, Elmira, New York, July 21 after an 8-months' illness.

C. H. KENNEDY

At the time of his death Kennedy was vice-president in charge of sales for The Kennedy Valve Manufacturing Company in Elmira, New York. He graduated with a degree in mechanical engineering from Cornell University in 1912. Upon graduation he entered the business founded by his father, worked through the ranks in several factory departments, was successively manager of the New York branch, sales manager of the company, and had been vice-president since 1929.

Kennedy is survived by his widow, five children, his mother, two brothers, and three sisters.

LeFebvre Vice-President and General Manager Cooper-Bessemer

The Cooper-Bessemer Corporation announces that at a meeting of its board of directors on August 25, Gordon LeFebvre, former American Locomotive Company executive, was elected its vice-president and general manager. In joining with one of this country's oldest and largest heavy machinery builders, LeFebvre fills a management vacancy created in May of this year by the untimely death of Charles B. Jahnke. B. B. Williams, who was recalled at that time to again take up active duties as head of the corporation, will retain the positions of president and chairman of the board of directors. At the same meeting, LeFebvre and L. F. Williams were elected directors of the corporation.

GORDON LeFEBVRE

LeFebvre is a graduate of Virginia Polytechnic Institute and attended the United States Military Academy at West Point, New York. From 1913 to 1914 he served as a special apprentice and machinist for the Northwestern Railway. During the years 1915 to 1919 he was affiliated with E. I. Dupont de Nemours and Company as machinist, master mechanic, and finally, mechanical superintendent.

In 1919 LeFebvre became associated with General Motors Corporation in its Chevrolet Division. He was in charge of construction of the Chevrolet plant and, later, responsible for production there, under William S. Knudsen. He was then elevated to the position of vice-president in charge of all General Motors Corporation activities in the Dominion of Canada, following which service he returned to the United States to assume the duties of vice-president in charge of operations at the company's Pontiac Division.

From 1932 to 1936, LeFebvre was consulting engineer with offices in Detroit, Michigan, and eventually became associated with A. J. Brandt, Inc. In 1937, he joined the American Locomotive Company as manager of its Diesel Engine Division at Auburn, New York, and served in that capacity until his recent decision to accept this new position with The Cooper-Bessemer Corporation.

Worthington Expands Purchase and Traffic Divisions

To meet the demands for executive direction imposed by a growing participation in the defense program, Worthington Pump and Machinery Corporation has appointed Carleton Reynell as general manager of purchases and traffic, Frederic W. Thomas as assistant general manager of purchases, and Dean K. Chadbourne as assistant general manager of traffic.

COFFING *"Safety-Pull"* HOISTS
For every lifting and pulling job

Today's demand on every industry requires that all plants be equipped with time and labor saving maintenance and production equipment. Coffing "Safety-Pull" ratchet lever hoists are especially designed for all types of construction and maintenance work. Wherever a lift or pull is needed the "Safety-Pull" will do the job safely, quickly and economically.

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Ratchet Lever, Spur Gear and Electric Hoists
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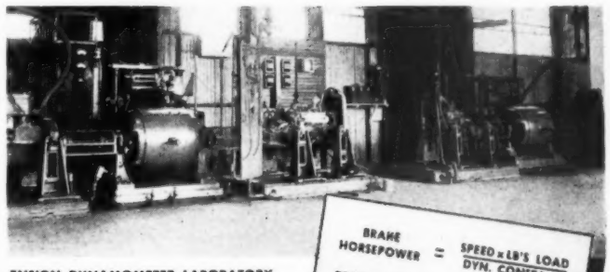

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Portable Rig Appoints W. S. Lightbourn Sales Manager

Effective September 1, W. S. Lightbourn has been appointed sales manager by Portable Rig Company, Houston, Texas, to fill the vacancy created by the resignation of L. D. Cain who has entered business for himself.

W. S. LIGHTBOURN

Lightbourn, who graduated from Georgia Tech in 1928, began his oil industry career the following year as an engineer for Vacuum Oil Company in Houston. In 1930 he joined Oil Well Supply Company to do sales and service work in east and southwest Texas, and in 1934 was employed by Portable Rig Company as manager of its Dallas branch office. In 1936 he was promoted to division manager of the East and West Texas Division. As sales manager, Lightbourn will make his headquarters in Houston.

Carl Weidner, Prominent Oil Figure, Passes Away

Carl R. Weidner, 58, chief engineer in the pipe line division of the Sinclair Refining Company, died August 20 in Independence, Kansas, of a heart attack.

Weidner was widely experienced in the engineering field and began as rodman with a civil engineering concern after graduation from Cornell University. He was successively employed in construction, as a draftsman, as assistant engineer with The Prairie Oil and Gas Company from 1904-08, as research assistant and as an instructor in hydraulics and sanitary engineering at The University of Wisconsin, as chief hydrographer with the Knoxville Power Company, in flood control work with Miami Conservancy District, Dayton, Ohio, and from 1916 to 1932 was chief engineer of The Prairie Pipe Line Company. From 1932 to 1936 he was chief engineer of Sinclair Prairie Pipe Line Company, Sinclair Prairie Pipe Line Company (of Texas), and Consolidated Pipe Line Company, Independence, Kansas. In 1936, Weidner became chief engineer for the Sinclair Refining Company, Pipe Line Department, Independence, Kansas.

CARL WEIDNER

Nomads to Be Hosts of Foreign Oil Men at A.P.I. Meet

Definite plans are being completed by the Los Angeles Chapter of Nomads to act as hosts to Nomads and foreign oil men at the American Petroleum Institute Convention to be held in San Francisco, California, November 3 to 7, inclusive.

Bart Gillespie is chairman of the general committee handling all details, assisted by Clarence Hill and Charlie Toll. Additions to this committee made during the last few days include Elmer Decker, Fred Ripley, Ted Sutter, Bill Bettis, Ernie Fowks, and Hi Cassidy.

In speaking of the Nomads' program for the coming convention, Ernie Fowks, president of the Los Angeles Chapter, said, "All Nomads recognize the opportunity presented for doing an outstanding and worthwhile job at San Francisco in November. To act as hosts for all foreign oil men visiting the Convention, as well as to Nomads from other chapters, involves a great deal of planning and hard and conscientious work on the part of the various committees. We are sure, however, that the task will be handled in a manner which will be a credit to the industry."

MEETINGS

National Petroleum Association, 39th Annual Meeting—September 17, 18, and 19, Hotel Traymore, Atlantic City, New Jersey.

Society of Automotive Engineers, National Tractor Meeting—September 25 and 26, Schroeder Hotel, Milwaukee, Wisconsin.

National Lubricating Grease Institute, Ninth Annual Meeting—September 29 and 30, Stevens Hotel, Chicago, Illinois.

California Natural Gasoline Association, Monthly Meeting—October 2, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles.

West Virginia Oil and Natural Gas Association, Annual Convention—October 2 and 3, Clarksburg, West Virginia.

National Safety Congress—October 6, 7, and 8, Stevens Hotel, Chicago, Illinois.

Texas Mid-Continent Oil and Gas Association, Annual Meeting—October 9, 10, and 11, Beaumont, Texas.

Indiana Independent Petroleum Association, Fall Convention and Old Timers Gathering—October 14 and 15, Hotel Severin, Indianapolis, Indiana.

American Association of Petroleum Geologists—October 16 and 17, Los Angeles, California.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—October 16, 17, and 18, Dallas, Texas.

National Stripper Well Association—October 20, Tulsa, Oklahoma.

Independent Petroleum Association of America, Twelfth Annual Meeting—October 20, 21, and 22, Tulsa, Oklahoma.

Society of Automotive Engineers, National Fuels and Lubricants Meeting—October 23 and 24, Mayo Hotel, Tulsa, Oklahoma.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—October 29 and 30, Los Angeles, California.

California Natural Gasoline Association—October 31, Los Angeles.

American Petroleum Institute, 22nd Annual Meeting—November 3, 4, 5, 6, and 7, San Francisco, California.

New Mexico Oil and Gas Association—December 3, Artesia, New Mexico.

Oklahoma Stripper Well Association—December 5, Tulsa, Oklahoma.

American Institute of Electrical Engineers, Southeastern District—December 3, 4, and 5, New Orleans, Louisiana.

Society of Automotive Engineers, Annual Meeting (and Engineering Display)—January 12, 13, 14, 15, and 16, 1942, Book-Cadillac Hotel, Detroit, Michigan.

Texas Oil and Gas Association—February 28, 1942, Wichita Falls, Texas.

American Society of Mechanical Engineers, Spring Meeting—March 23, 24, and 25, 1942, Houston, Texas.

National Petroleum Association, Thirty-ninth Semi-Annual Meeting—April 16 and 17, 1942, Cleveland, Ohio.

Petroleum Industry Electrical Association—April 22, 23, and 24, 1942, Shreveport, Louisiana.

American Association of Petroleum Geologists, Twenty-seventh Annual Meeting—April 21, 22, 23, and 24, 1942, Cosmopolitan Hotel, Denver, Colorado.

International Petroleum Exposition—May 16, 17, 18, 19, 20, 21, 22, and 23, 1942, Tulsa, Oklahoma.

American Society of Mechanical Engineers, Semi-Annual Meeting—June 8, 9, 10, and 11, 1942, Cleveland, Ohio.

American Society of Mechanical Engineers, Fall Meeting—October 12, 13, and 14, 1942, Rochester, New York.

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GOTT Water Coolers are the convenient way to keep drinking water handy to the worker, protect it from impurities. Their exclusive construction keeps water cool for long periods. Snug fitting large removable top, handy non-leaking push button faucet. GOTT Water Cans for handy field use.
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Nearly every major change in drilling technique brings new importance to **accurate weight control . . .**

Yesterday, many drillers applied all the weight on the bit that the equipment could stand — often far more.

Today, drillers hold the pipe "in tension," letting bit and drill collars do the work . . . saving terrific strains on pipe, and cutting power costs.

The extremely fine weight, speed and torque measurements required in this technique largely determine efficiency and economy of making hole. **That's why you'll find the Martin-Decker "Sealtite" used everywhere, to make these important measurements accurately!**

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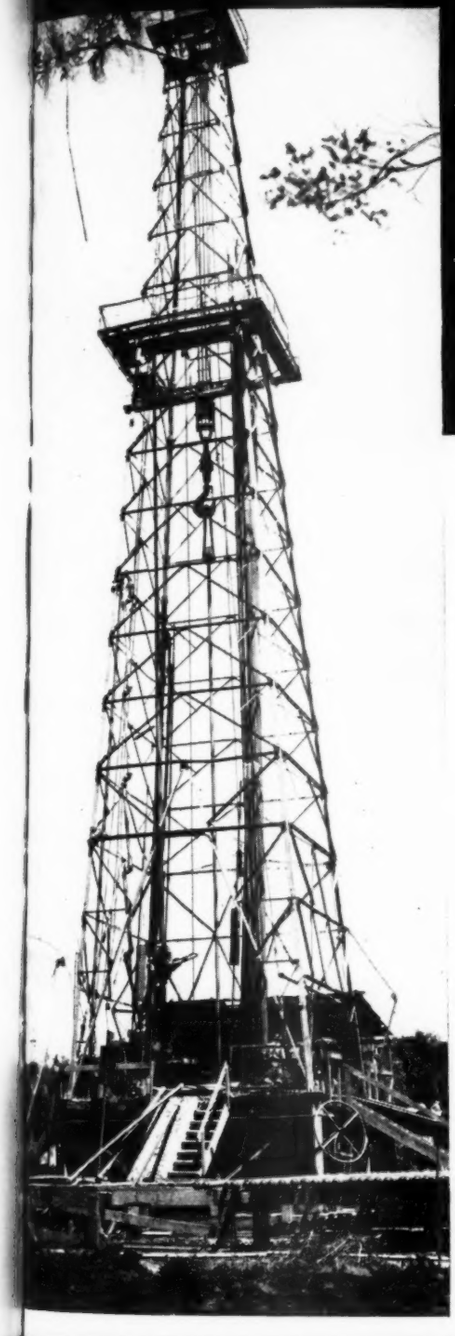

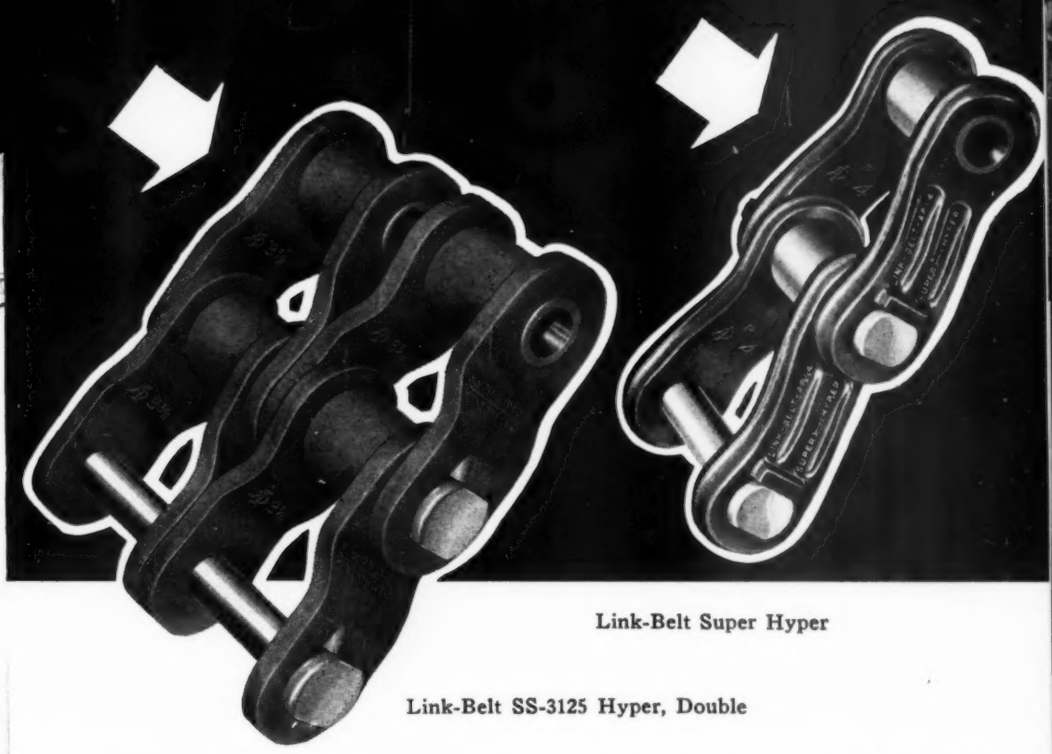

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Dan Griffin Speaks for Steel...

★ Below are quoted the remarks of Dan F. Griffin, a steel worker in the Campbell Works of The Youngstown Sheet and Tube Company, made recently at a meeting of a Youngstown, Ohio, civic club. Reflecting the attitude of Youngstown employees, his words should be of interest to the users of Youngstown steel.

"Today, the eyes of the world are turned upon the ever-increasing conflagration in Europe. We realize that our nation has undertaken the gigantic task of transforming a peace-time nation into a nation geared to total national defense.

"The steel mill employee is playing an ever-increasing and more important role in this task; and the American steel man is tops in the industry.

"We know that as much depends upon the skill and devotion of these steel mill employees as on our armed forces on land, sea, and in the air. To a man, the steel mill employees of America appreciate they are among the highest paid workers in the world. Their working conditions are the best.

"The American steel worker has plenty of leisure time to do as he will. He can work in his garden; he can seek any form of entertainment, not only for himself but also for his family. He can study to improve himself, and quite frequently does. He is in no way limited.

"The highest office in our land has been occupied by men of the most humble birth. Freedom in America has never had a price, but its rewards are unlimited. Your steel mill employee knows that he cannot buy freedom—he must think freedom—he must work for freedom.

"We treasure our American way of life as we have it today. We're prepared to go to any lengths to preserve for ourselves and for our children that tranquility, that comfort, that peace, which we have enjoyed in years past.

"We're willing to pay our share in money or labor—yes, we are already lending. We want our boys to serve—they're already being trained for service.

"Our steel workers' creed should be an all-out effort to procure peace for ourselves and for the rest of the world. If we must work harder or longer to produce the steel necessary to insure that peace, then we're ready and anxious to do our bit, for in that way only do we serve.

"The Army needs steel—we'll make it.

"The Navy needs steel—we'll make it.

"The Air Force needs steel—we'll make it.

"The whole world needs steel, and steel workers will make it, for the real steel man is a true American. He will never do or think anything to jeopardize America. He will do everything in his power to preserve America for Americans and Americanism.

"We'll remember, always, that the men of the Army, the men of the Navy, the men of the Air Force, those defending democracy and the men of production are all ONE.

"We're 'Sammies' on guard!

"The U.S. in United States means US."

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The Petroleum Engineer, published monthly August through June, semi-monthly in July, by The Petroleum Engineer Publishing Company, seventh floor Allen Building, Dallas, Texas. Subscription price, $2.00 per year, $3.00 for 2 years, 25c a copy. Entered as second-class mail matter May 1, 1932, at the post office at Dallas, Texas, under the act of March 3, 1879.

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Keeping pace with progress in the oil industry, the Universal Atlas Cement Co. announces that to all the original outstanding characteristics of retarded set, fluidity, pumpability, and high factor of safety, improved Unaflo now provides—

GREATER uniformity in composition;

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GREATER uniformity in rate of stiffening;

GREATER uniformity in retardation of setting time as hole temperature increases;

GREATER protection for your costly investment already made in tools and well;

GREATER insurance against loss in cases of unforeseen shutdowns.

UNIVERSAL ATLAS RESEARCH HAS PROVIDED A STILL BETTER, SAFER OIL-WELL CEMENT

SEE NEXT PAGE

FIELD PERFORMANCE AND LABORATORY TESTS SHOW THE SUPERIORITY OF IMPROVED UNAFLO

FOR SIX YEARS Unaflo oil-well cement has made enviable records in all kinds of cementing jobs—cementing casing, plug-back operations, squeeze cementing, cementing liners, and recementing operations. It has been used successfully to depths exceeding 14,000 feet. It has performed successfully under pressures up to and exceeding 7,500 pounds, and at temperatures from 100° to 350° F. It has remained fluid and pumpable after unforeseen delays and shutdowns.

Field performance shows these advantages are true also for *improved* Unaflo. Here's why:

1—*Improved Unaflo reacts more uniformly to various types of mixing water;*

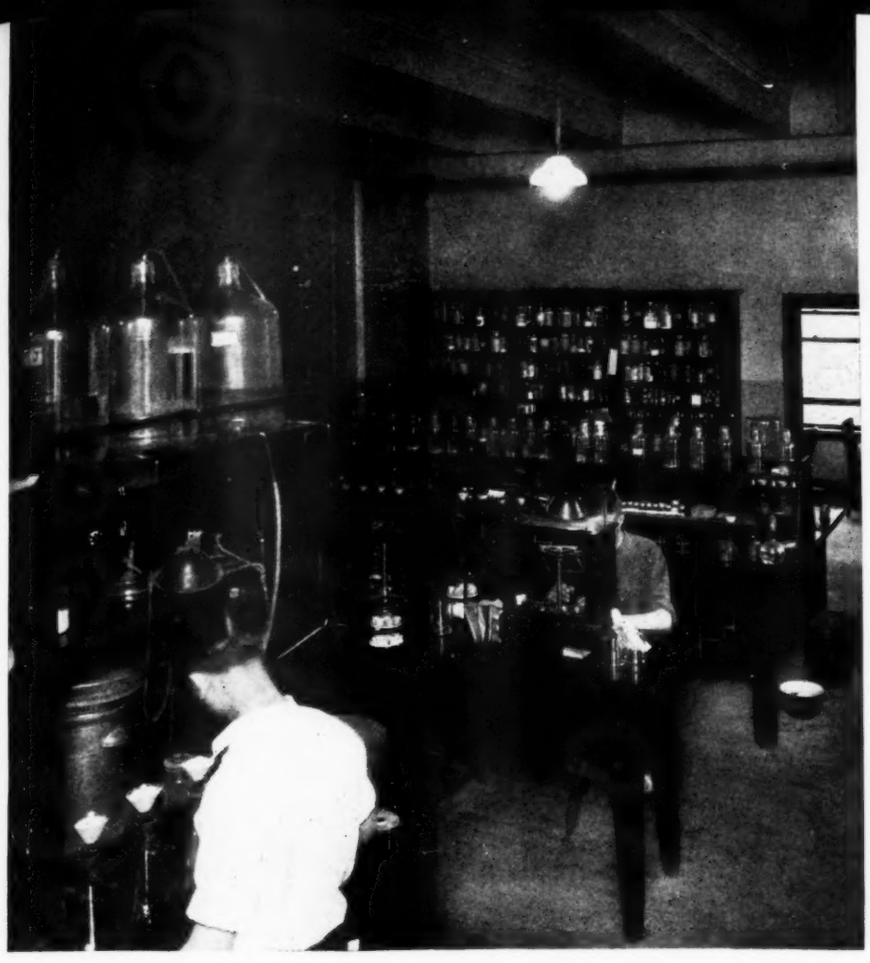
2—*Improved Unaflo has a smoother, more uniform rate of stiffening;*

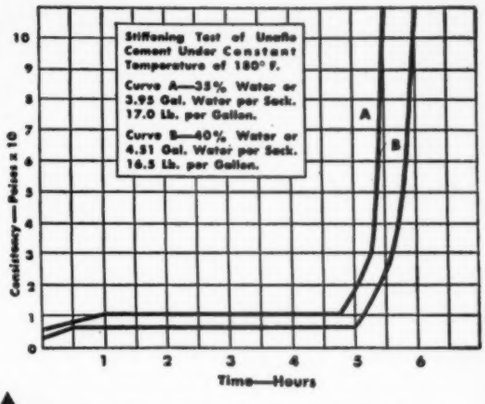
3—*Improved Unaflo has a rate of retardation which decreases more uniformly as the hole temperature increases;*

4—*Improved Unaflo provides a higher factor of safety even in cases of unforeseen delays and shutdowns.*

The Unaflo of today is even more uniform in composition, more uniform in field performance and an even better, safer oil-well cement than the original Unaflo—the first retarded oil-well cement.

Use in the field as well as tests in the laboratory have shown that with *improved* Unaflo the initial stiffening is delayed with increased uniformity in the period of retardation. This is true under varying temperature, time, kind of mixing water and down-the-well conditions. This results in the following:





Stiffening Test of Unaflo Cement. Unaflo mixes and pumps easily with 17-lb. cement slurry. Curve shows that it allows elimination of ½ gallon of mixing water per sack of cement and remains easily pumpable for several hours regardless of well temperature, and so provides a high factor of safety with a strong, dense, heavy slurry. This is why Unaflo is chosen so often for oil-well cementing, including deep, tough jobs.

Surveys of cementing problems, inquiries directed to oil companies and cementing companies, and years of research preceded the production of Unaflo, the first retarded oil-well cement. That this was the type of cement desired is best evidenced by the 2100% increase in its use by oil companies since it was introduced in 1936. Even so, Universal Atlas was not satisfied. Studies and research continued in order to make a good product still better. The result is your gain. The Unaflo of today is more uniform in composition, more uniform in field performance, and an even better safeguard for all kinds of cementing and recementing jobs.

CHARACTERISTICS OF *IMPROVED* UNAFLO

As shown in the field and laboratory

REACTS uniformly with different types of mixing water found on different jobs;

REQUIRES less mixing water;

PERMITS use of heavier slurry that assures denser, stronger, more impermeable seal;

MAINTAINS fluidity regardless of well temperature and subsurface conditions;

REMAINS easily pumpable after shutdowns for extended period;

IS DEPENDABLE for squeeze jobs;

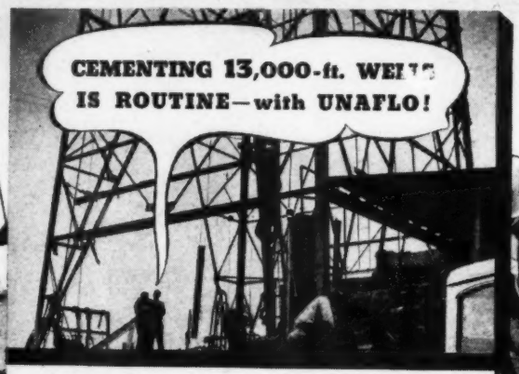
PROVIDES more certain and higher factor of safety.

. . .

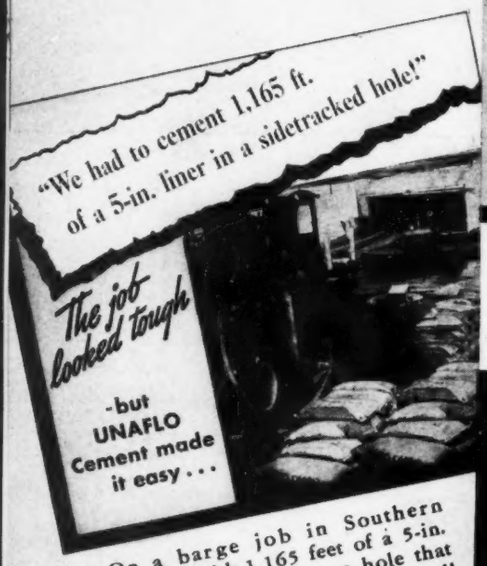
Field performance and laboratory tests show that *improved* Unaflo is even more reliable than the original Unaflo in overcoming the unpredictable hazards of cementing, and in minimizing the chances of failures.

How to get UNAFLO

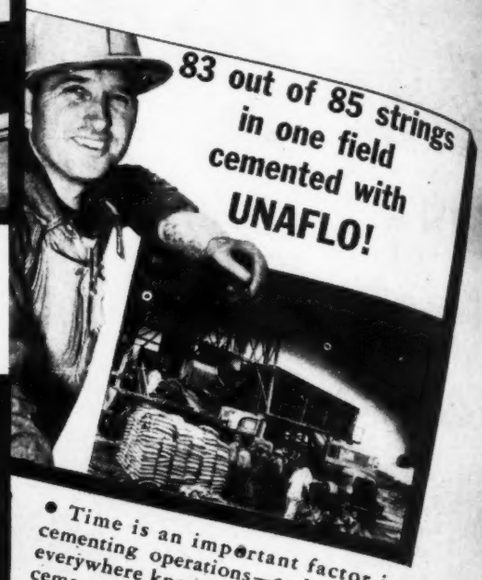
Unaflo, the *improved* retarded oil-well cement, is handled by representative dealers throughout the oil field. Use it to protect your investment in tools and well. Get it from your dealer



• Hundreds of deep, high-temperature holes are handled successfully every year, with Unaflo on the job. Even 14,000 feet is cemented easily with this oil-well cement with the retarded set.



• On a barge job in Southern Louisiana, with 1,165 feet of a 5-in. liner to be cemented in a hole that was sidetracked — Unaflo oil-well cement was specified. The result? 100% success!

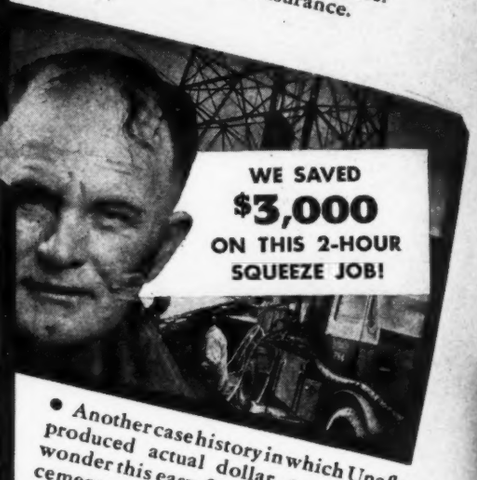


• Time is an important factor in cementing operations—and oil men everywhere know that Unaflo oil-well cement makes a mighty big difference. Its retarded set is good insurance.

• Plug-back cementing, on wells showing salt water, was 100% successful in a Texas oil development—because Unaflo oil-well cement was specified on the job.

WHAT! A 2¼-HOUR SHUT-DOWN WITH CEMENT IN 4,060 FEET OF 2⅜-INCH TUBING?
YEAH. BUT WE USED UNAFLO CEMENT . . . AND WHEN THE JOB WAS DONE, THAT BACKWASHED OUT—WITH NORMAL PRESSURE!

• One hour and 23 minutes *after* cementing started, mechanical trouble forced a shutdown. Repairs took 2 hours and 14 minutes. Unaflo, the retarded oil-well cement remained fluid—and pumpable. The job was saved.



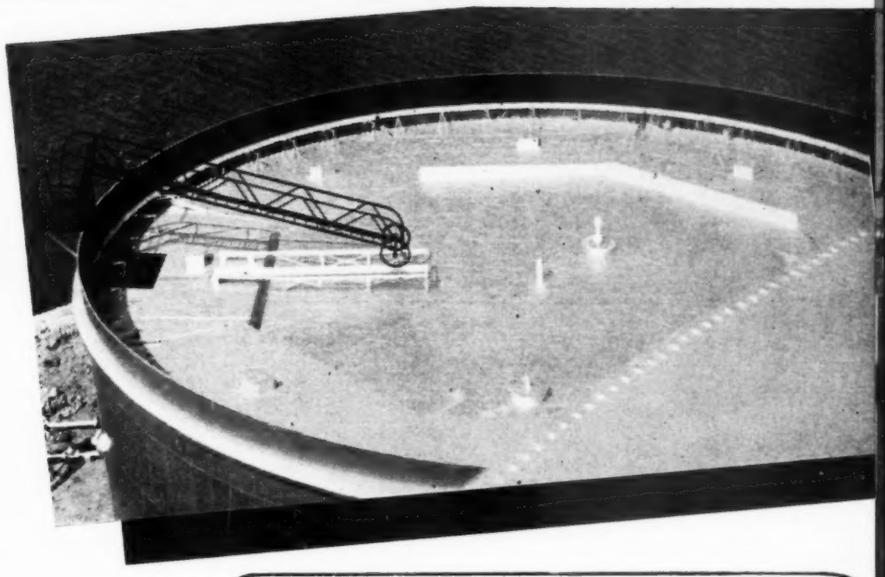
• Another case history in which Unaflo produced actual dollar savings. No wonder this easy-flowing, hard-setting cement with the retarded set leads the field wherever oil is found.

These are days to take the guessing out of cementing operations. Do it with *improved* Unaflo oil-well cement — and play safe. Get it from your dealer. Universal Atlas Cement Co. (United States Steel Corporation Subsidiary), Amicable Bldg., Waco; Oklahoma City; Kansas City; Chicago; Birmingham.

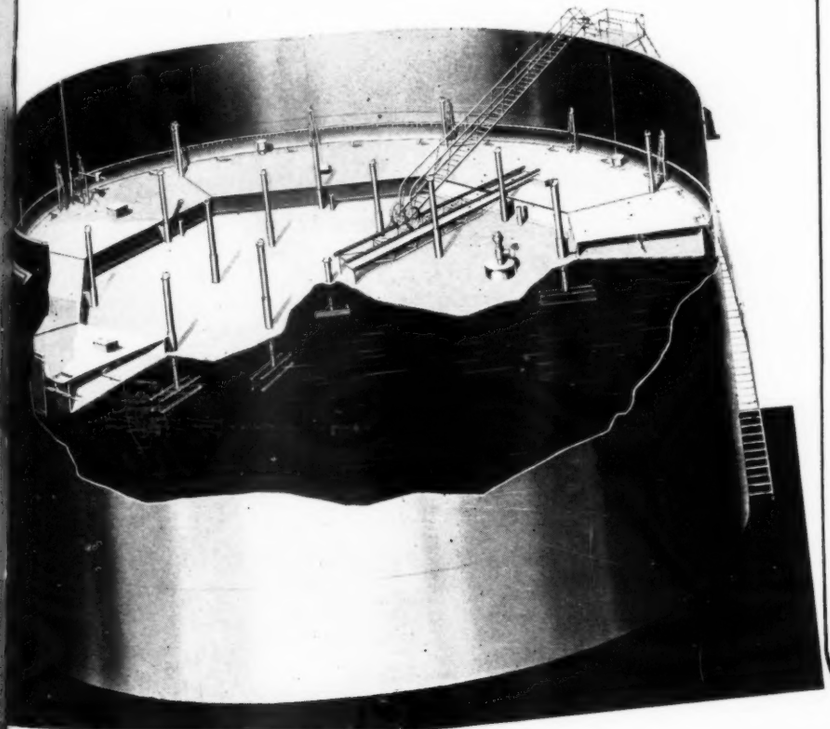
UNIVERSAL ATLAS OIL-WELL CEMENTS

The WIGGINS PONTOON ROOF

. an Effective Blanket For Stopping EVAPORATION LOSSES and Reducing FIRE HAZARD



THE WIGGINS PONTOON ROOF stops evaporation loss and reduces fire hazard by eliminating the vapor space in an oil tank. It floats directly on the liquid, blanketing the surface at all levels. Simply constructed, these roofs consist primarily of a pontoon deck, a special type of seal which closes the space between the deck and the tank shell, roof supports, ladder and a guide to prevent the roof from rotating. Pontoon roofs are applicable to riveted or welded tanks 15 ft. in diameter or larger, for new or existing steel tanks serving pipe line stations, refineries, bulk stations, field storage, and marine terminals.



EVAPORATION LOSS PREVENTION

● Listed below are some of the ways in which Wiggins Pontoon Roofs are utilized to prevent evaporation losses and to reduce the possibility of fire hazard.

Breathing Losses—Whenever increasing temperatures cause expansion in the vapor space of a fixed-roof tank, vapor is vented to the atmosphere, causing so-called "breathing" losses. Pontoon roofs stop such losses by eliminating the vapor space.

Filling Losses—When tanks with fixed roofs are filled, vapor is displaced through the roof vents. In filling tanks equipped with pontoon roofs, no vapor is displaced because the roof rests directly on the liquid surface. No loss occurs from the small space between the roof and the tank shell because the volume of this space remains constant, even when the roof is rising.

FIRE PREVENTION

The Wiggins Pontoon Roof prevents fire by eliminating the conditions which would permit the contents of the tank to burn. The liquid beneath the deck cannot become ignited because there is no oxygen present to support combustion. Since floating roof tanks have open tops, an explosive mixture is not likely to form above the roof because there is nothing to confine vapors to this area. The fire preventative ability of pontoon roofs is recognized by the Underwriters' Laboratories of Chicago, Illinois.

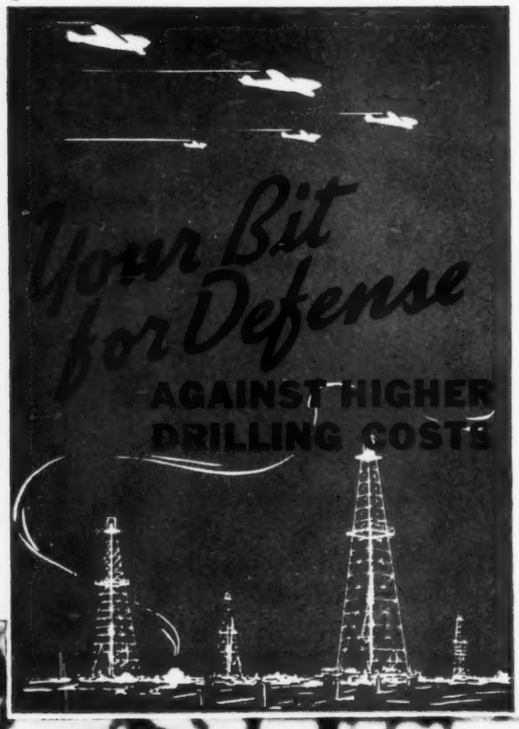
CHICAGO BRIDGE & IRON COMPANY

HOUSTON.....5637 Clinton Drive
TULSA.....1634 Hunt Bldg.
BIRMINGHAM.....1570 N. 50th Street
HAVANA.....402 Edificio Abreu

CHICAGO.....2481 McCormick Bldg.
DETROIT.....1538 Lafayette Bldg.
CLEVELAND....2251 Builder's Exchange
PHILADELPHIA....1635-1700 Walnut St.

NEW YORK....3373-165 Broadway Bldg.
BOSTON....1535 Consolidated Gas Bldg.
SAN FRANCISCO.....1064 Rialto Bldg.
LOS ANGELES.....1446 Wm. Fox Bldg.

Fabricating Plants in BIRMINGHAM, CHICAGO and GREENVILLE, PA.



Bit after Bit, Hole after Hole

REED ROCK BITS

are Dependable!

You can do your "bit" in your own defense against mounting drilling costs by using Reed Rock Bits on well after well.

THESE 7 TYPES OF REED ROCK BITS ARE ESPECIALLY DESIGNED FOR DEPENDABLE DRILLING

T—for Soft to Medium and sticky formations

M—for the Medium Hard Formations

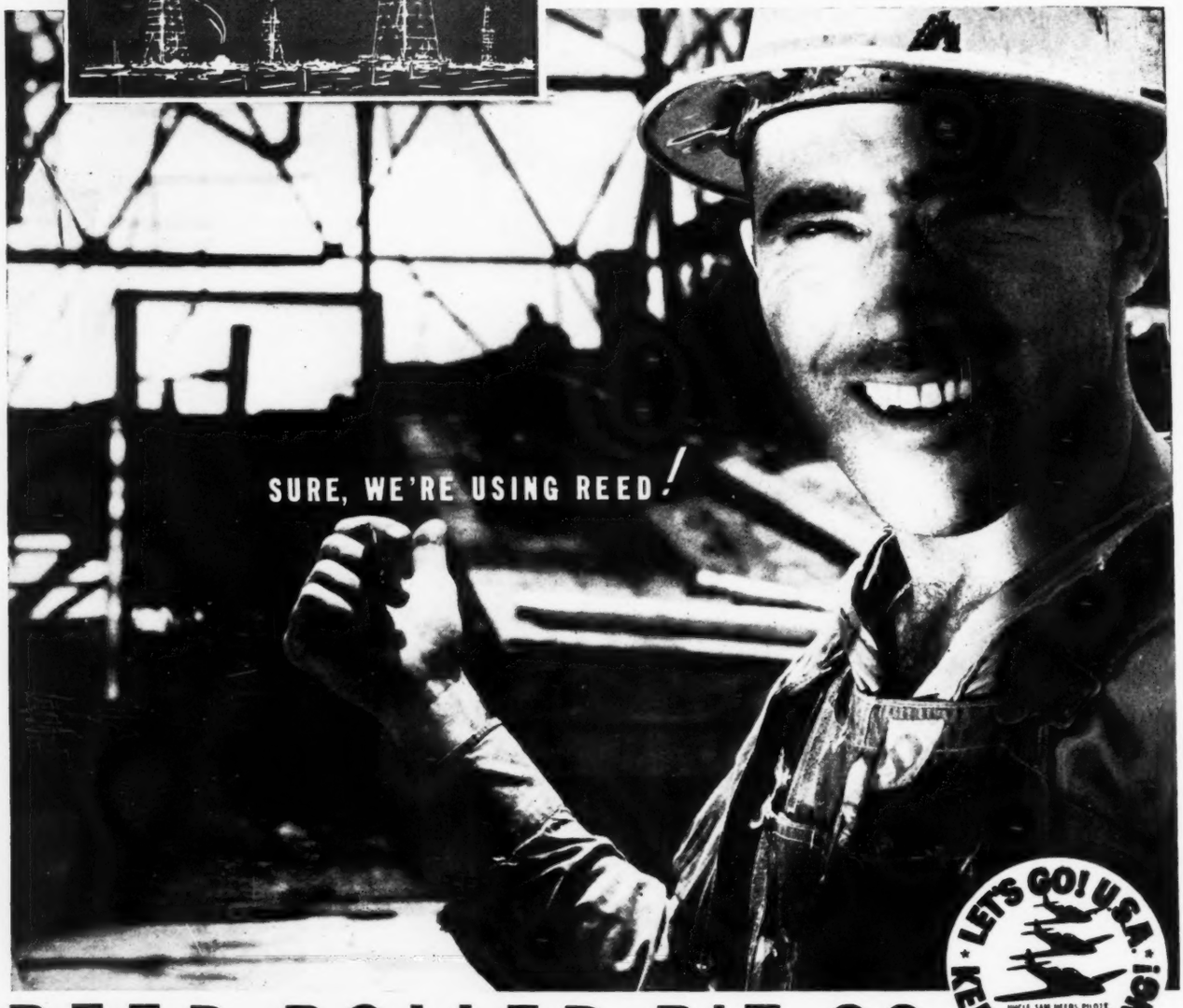
L—Medium Hard and Abrasive formations

H —for the Abrasive and broken formations

2 —for the Medium hard formations that chip easily

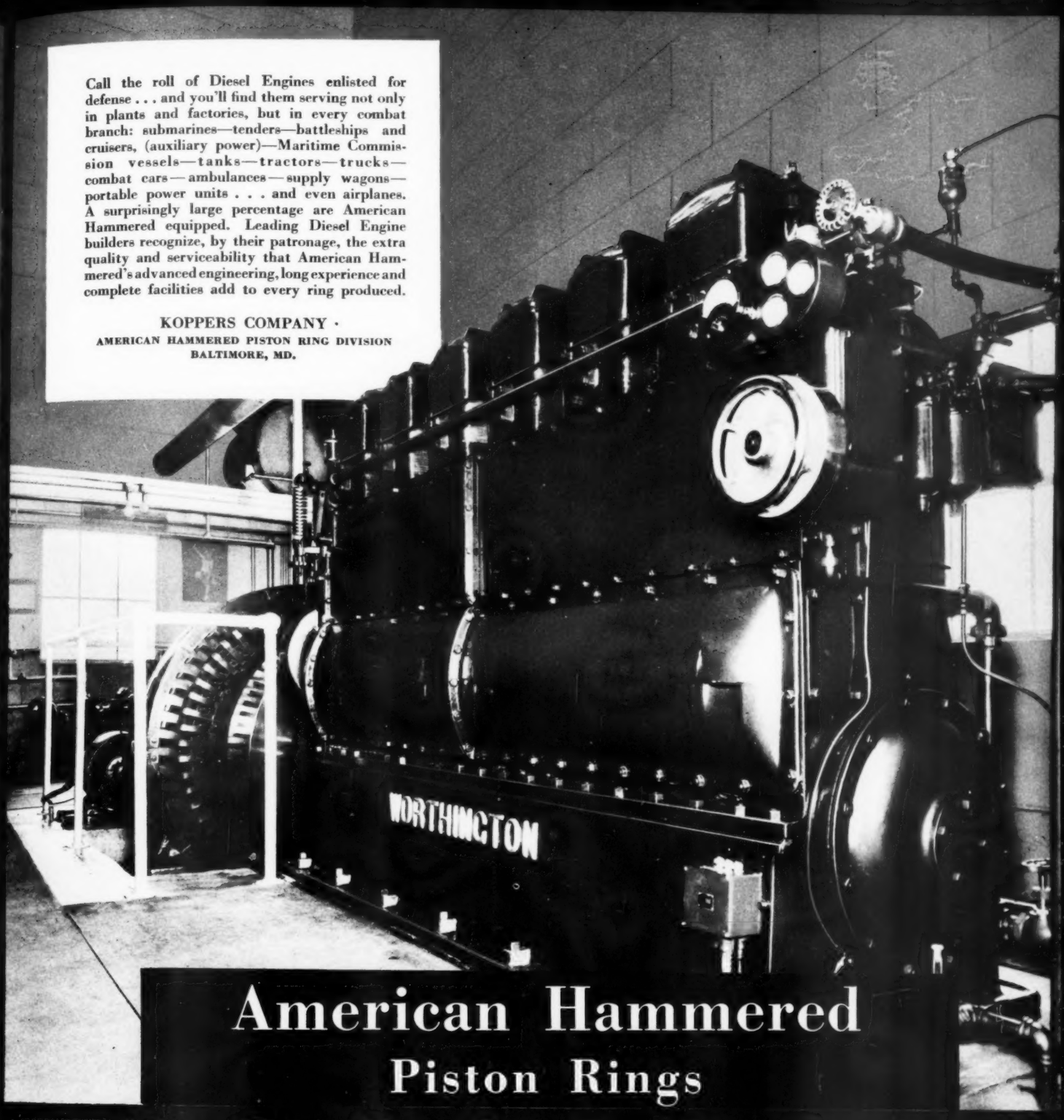
2C—for the Hard Abrasive formations

2D—for the extremely Hard Formations



REED ROLLER BIT CO.

P. O. BOX 2119 HOUSTON, TEXAS



Call the roll of Diesel Engines enlisted for defense . . . and you'll find them serving not only in plants and factories, but in every combat branch: submarines—tenders—battleships and cruisers, (auxiliary power)—Maritime Commission vessels—tanks—tractors—trucks—combat cars—ambulances—supply wagons—portable power units . . . and even airplanes. A surprisingly large percentage are American Hammered equipped. Leading Diesel Engine builders recognize, by their patronage, the extra quality and serviceability that American Hammered's advanced engineering, long experience and complete facilities add to every ring produced.

KOPPERS COMPANY ·
AMERICAN HAMMERED PISTON RING DIVISION
BALTIMORE, MD.

American Hammered
Piston Rings

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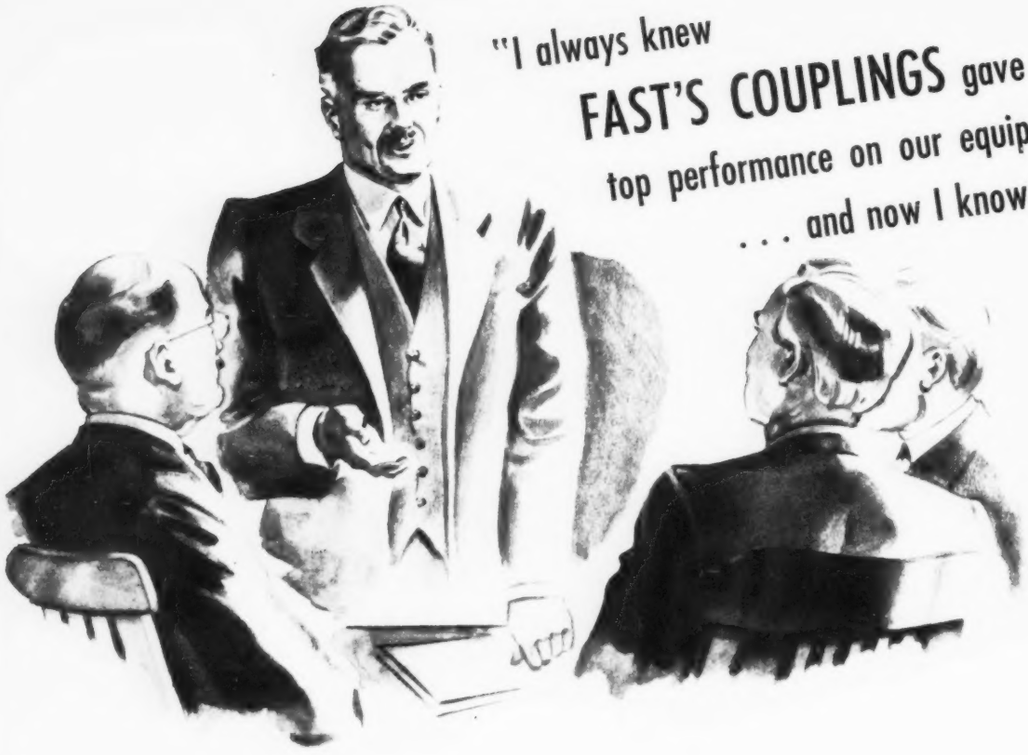
FIRST CLASS PERMIT NO. 1046, SEC. 510 P. L. & R., PITTSBURGH, PA.

KOPPERS COMPANY
7320 Koppers Building (19)
Pittsburgh, Pa.



"I always knew
FAST'S COUPLINGS gave
top performance on our equipment
. . . and now I know why."

"Gentlemen, if you could see Fast's Couplings made—as I did when I visited their plant—you would better understand why our operating men swear by 'Fast's.'

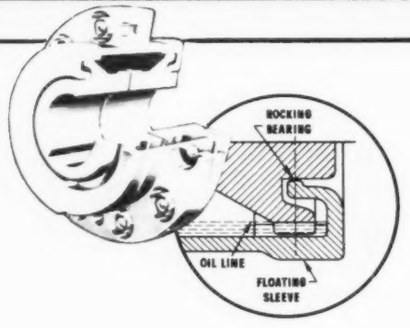
"You'd see an entire shop, from forging to finishing, tooled and manned to do just one job . . . *right.*

"You'd see inspectors make 56 individual inspections on every coupling produced, checking tolerances down to split thousandths with micrometers, pin gauges, and indicating machines.

"You'd see the final 12-point verification before shipment, to assure that size, key-way and bore dimensions, and other points conform 100% to customer specifications."

This extra care in manufacture shows up in extra performance. The safest, surest way to avoid operating difficulties is to specify *genuine* Fast's Couplings on the machinery you purchase.

KOPPERS COMPANY
BARTLETT HAYWARD DIVISION
BALTIMORE, MARYLAND



These views show the exclusive design features of Fast's Couplings. The load-carrying surfaces are protected against wear by a positive film of oil. This oil is kept permanently clean by rocking bearings, which make precise metal-to-metal contact and are located in the one position where they form permanent dust and moisture-proof seals. Only *genuine* Fast's Couplings have these important advantages.

a KOPPERS product

OPPERS COMPANY
320 Koppers Bldg., (19) Pittsburgh, Pa.

lease send me the literature checked:

ame.....

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- ☐ "Piston Rings for Diesel Engines"
- ☐ "Piston Rings for Compressors"
- ☐ "Automotive Ring Set-ups"
- ☐ "How to Order Piston Rings"
- ☐ "Fast's Self-aligning Couplings"
- ☐ "Oil from Water"
- ☐ "Pressure-treated Timber"
- ☐ "Pressure-treated Poles"
- ☐ "Tar-base Paints"
- ☐ "Purification System for Liquid Hydrocarbons"
- ☐ "Phenolate Gas-Purification Process for Removal and Recovery of Hydrogen Sulfide"
- ☐ "Modified Thylox Purification Process for Low-sulfur Gas"

Fill out and mail

"CAMERON FLEX-SEAL MUD VALVES ARE SAVING US 90% ON MUD VALVE MAINTENANCE

Otis W. Dyer
DRILLING CONTRACTOR

O. W. DYER
Drilling Contractor

Telephone C-6011
1606 SECOND NATIONAL BANK BUILDING HOUSTON, TEXAS

April 11, 1941.

Cameron Iron Works, Inc.,
711 Milby St.,
Houston, Texas.

Gentlemen:

Pursuant to your request for maintenance and operating data on the "Flex-Seal" mud valves now in service on our rigs, we are glad to be able to give credit where credit is due.

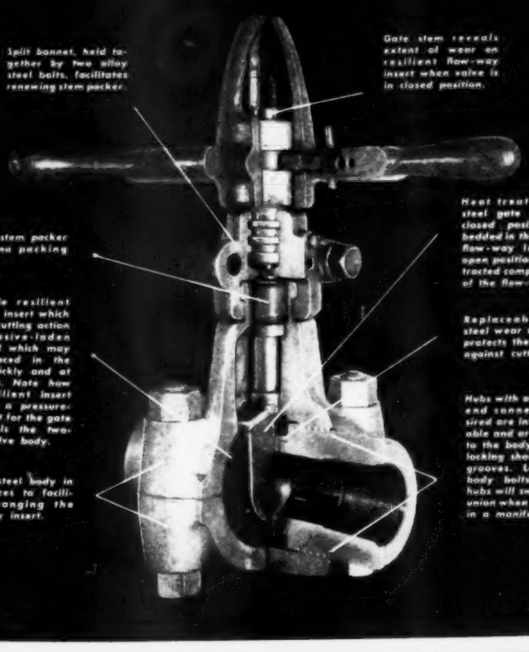
According to our records, your valves require approximately 90% less maintenance expense than any other mud valve we have ever used. To date, all of our eight rigs are completely equipped with "Flex-Seal" valves and they will be installed on a ninth rig, now being assembled, in the near future.

The fact that your valve opens and closes easily under pressure and may be completely overhauled at the rig also deserves a full measure of praise.

Please feel free to pass this information along to other operators, many of whom are no doubt experiencing difficulty with conventional plug valves and stop cocks.

Very truly yours,
O. W. Dyer, Sr.
O. W. Dyer

O. W. Dyer, Jr.
Otis W. Dyer Jr.


Split bonnet, held together by two alloy steel bolts, facilitates renewing stem packer.
Gate stem reveals extent of wear on resilient flow-way insert when valve is in closed position.
Lip-type stem packer requires no packing gland.
Heat treated alloy steel gate shown in closed position embedded in the resilient flow-way insert. In open position, it is retracted completely out of the flow-way.
Renewable resilient flow-way insert which absorbs cutting action of abrasive-laden fluid and which may be replaced in the field, quickly and at low cost. Note how the resilient insert provides a pressure-tight seat for the gate and seals the two-piece valve body.
Replaceable alloy steel wear ring which protects the hub ends against cutting.
Forged steel body in two pieces to facilitate changing the flow-way insert.
Hubs with any type of end connection desired are interchangeable and are attached to the body by interlocking shoulders and grooves. Loosen the body bolts and the hubs will swivel like a union when making up in a manifold.

Now Available in
4000 LB. TEST MODEL
Similar to
6000 LB. TEST MODEL
Shown at Left

U. S. Army four-engine Bomber — the famous "Flying Fortress."

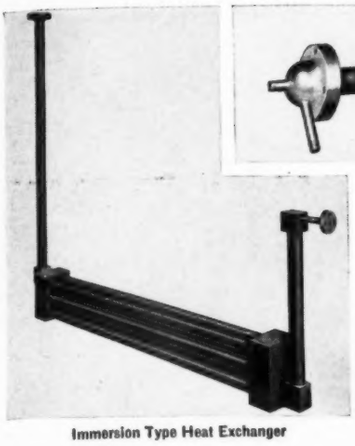
The Bomber Crew In the Air . . .
The Derrick Crew On the Ground . . .

They may not know each other, but they are "buddies"—one crew on the ground, the other in the air. The crew on the

derrick floor, using Hughes Rock Bits, is drilling for the oil so necessary to keep their buddies in the air aloft.

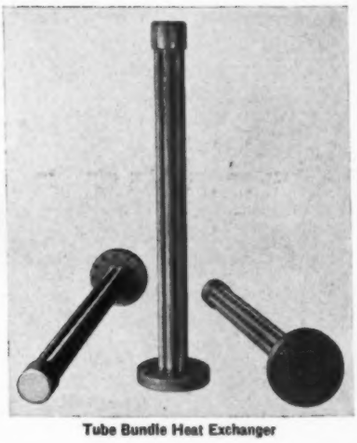
Hughes Tool Company • Houston

Bayonet Type Heat Exchanger



Immersion Type Heat Exchanger

Rapid Transfer of Heat



Tube Bundle Heat Exchanger

AND FREEDOM FROM CORROSION ARE OBTAINED BY USING

Karbate* NO. 2

TRADE-MARK

PIPE AND FITTINGS

FOR THE CONSTRUCTION OF HEATING OR COOLING COILS, EVAPORATORS AND OTHER HEAT EXCHANGE EQUIPMENT USED IN CONTACT WITH CORROSIVE MATERIALS

* "Karbate" is the trade-mark for a carbon or graphite base material impervious to seepage of fluids under pressure.

● "Karbate" No. 2 pipe has heat transfer properties equal to steel pipe of corresponding diameter. It is unaffected by salt water as well as most acids, alkalies and other corrosive materials.

Hundreds of heat exchangers of "Karbate" construction are in successful use. These represent many varied types, a few of which are illustrated on this page.

Elements for Shell and Tube Type Heat Exchanger

Return Bend Cooling Coil

National Carbon Co., Inc.
Cleveland, Ohio.

Gentlemen: Please send me information on the use of "Karbate," Carbon or Graphite materials for the application named.

APPLICATION CONSIDERED

NAME

FIRM

CITY STATE

PE

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

UCC

Carbon Sales Division, Cleveland, Ohio

GENERAL OFFICES

30 East 42nd Street, New York, N. Y.

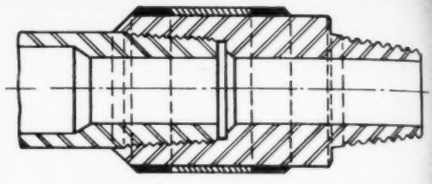
BRANCH SALES OFFICES

New York, Pittsburgh, Chicago, St. Louis, San Francisco

If tool joints in *your* strings of drill pipe are wearing away rapidly under today's punishing service requirements, then investigate the Stoody method of hard-facing those joints for *longer* wearing life . . . lower drilling and maintenance costs!

Tool joint engineers are reporting up to *double* normal life from tool joints hard-faced with Stoody Alloys. Electric Tube Borium and Coated Stoody Self-Hardening are the metals used. They're applied either directly to the tool joint surface, or to a recess machined into the tool joint, as desired. Whatever the method used, these Stoody Alloys are not only reducing tool joint wear under the toughest conditions, but they're also maintaining over-all joint strength and correct elevator contour *longer—two mighty important features!*

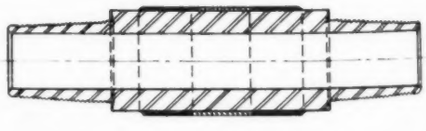
So if tool joint wear is a problem with you, write for the special Stoody Engineering Bulletin just issued which tells about the Stoody methods of hard-facing tool joints . . . recommends methods and procedures to meet any operator's requirements. It's yours for the asking!



Integral Tool Joints built up with Stoody High Carbon and hard-faced with Coated Stoody Self-Hardening. Illustrated above is method of application. After joints have been preheated to approximately 300° F., the metal is applied directly to the surface for a depth of about 3/16" Coated Stoody Self-Hardening is applied near the ends of the collar, Stoody High Carbon in the center This method is used successfully throughout Mid-Continent fields

These worn double-pin tool joints have been rebuilt and hard-faced with Coated Stoody Self-Hardening and Stoody High Carbon. The deposit may be as thick as 1/8" to 1/4", depending upon extent of wear This application is not only excellent for *reclaiming* old joints, but also enables them to outwear new ones.

This schematic drawing at right shows method of rebuilding and hard-facing worn double-pin tool joints Joints are preheated to approximately 300° F. before starting to weld. Success with this method has been outstanding in Mid-Continent territory.

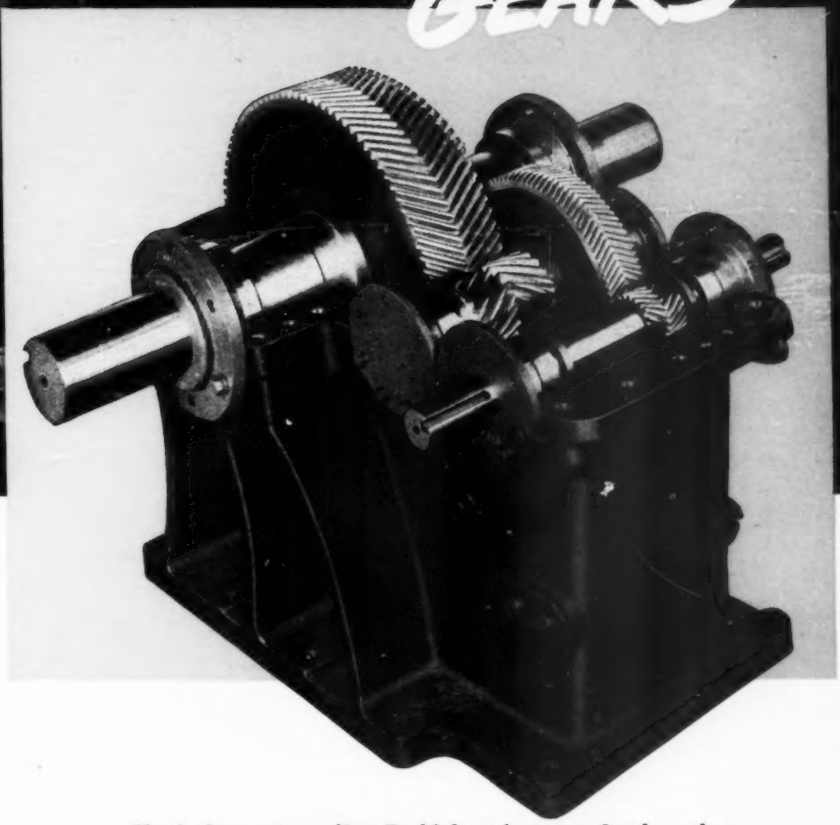


STOODY COMPANY • 1134 West Slauson Avenue • Whittier, California

STOODY COMPANY *Hard Facing Alloys*

ALL BETHLEHEM PUMPING UNITS

have FORGED-STEEL GEARS



FORGED-STEEL GEARS have uniform metal density. They're strong, tough, right for long, heavy-duty service. There are no treacherous hidden blow holes in them, no unseen shrinkage cracks. They are free from the excess internal stresses that can cause serious operating inefficiency and breakdown.

The extra life and better service Bethlehem provides with forged-steel heat-treated reducer gears are mighty important. But they're only part of the profit-making features built into all Bethlehem Pumping Units.

Check these outstanding Bethlehem features. See how they add up to trouble-free low-cost operation.

No welds at critically-stressed sections.

Rubber-mounted connection of walking beam to provide protection from well shocks on smaller units.

Built-in true alignment of entire unit without the use of shims.

Double-cone adjustable equalizer bearings.

All power transmitted to pitmans through straight and tapered roller bearings.

BETHLEHEM STEEL

Call **BETHLEHEM SUPPLY COMPANY** for Service

Offices or Stores—*Illinois*: Grayville, Salem, St. Elmo; *Kansas*: Chase, Great Bend, Russell, Wichita; *Louisiana*: Houma, Lake Charles, New Iberia, Shreveport; *New Mexico*: Artesia, Hobbs; *Oklahoma*: Fittstown, Maud, Oklahoma City, Seminole, Tulsa, Wewoka; *Texas*: Alice, Avoca, Borger, Corpus Christi, Dallas, Freer, Ft. Worth, Houston, Kemp City, Kilgore, La Ward, Midland, Monahans, Odessa, Pampa, Seminole, Wichita Falls.

HAZARD WIRE LINES HAVE SERVED ALL INDUSTRY...

GREEN STRAND SIGNIFIES SAFETY

Ever since 1846 Hazard has been making quality wire rope. That's nearly a century. That's a long time —a lot of experience. A product *has* to be good to maintain its name through three generations. It *has* to be good to keep customers coming back for Hazard ropes, *continuously*, for 30, 40, and 50 years. A product *has* to be good to merit such customer loyalty.

Now as to specific ropes:—

HAZARD LAY-SET Preformed Green Strand is more and more becoming the standard rotary drilling line in all fields because it lasts longer—resists whipping—makes possible faster round trips. LAY-SET Preformed handles easier, spools better, *is safer*. Hazard Lay-Set has proved its superiority over and over again in practically *all* fields. And when you use Green Strand LAY-SET, you know it is made of Improved Plow Steel—the long-life, greater dollar value line.

HAZARD "NONPARELL" has long been preferred by cable tool drillers. This is one of the lines that is backed by nearly a century of wire rope making experience—known to all the "old timers" as well as the younger drillers, tool pushers and superintendents as the line that gets the job done. Hazard men are wire line engineers. They know the exact rope construction for each application. They will be glad of the opportunity to help you.

★ *The Green Strand Identifies Hazard Wire Ropes made of Improved Plow Steel*

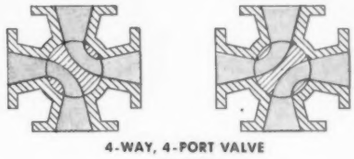
HAZARD WIRE ROPE DIVISION • *Established 1846* • **WILKES-BARRE, PENNSYLVANIA**

AMERICAN CHAIN & CABLE COMPANY, Inc.

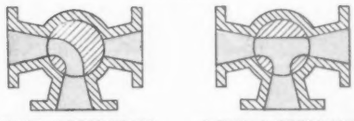
Branches or Distributors in All Important Oil Fields

FOR SIMPLIFIED SWITCHING...

Install Multiport Valves

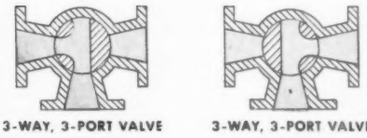


4-WAY, 4-PORT VALVE
90° TURN



3-WAY, 2-PORT VALVE
90° TURN

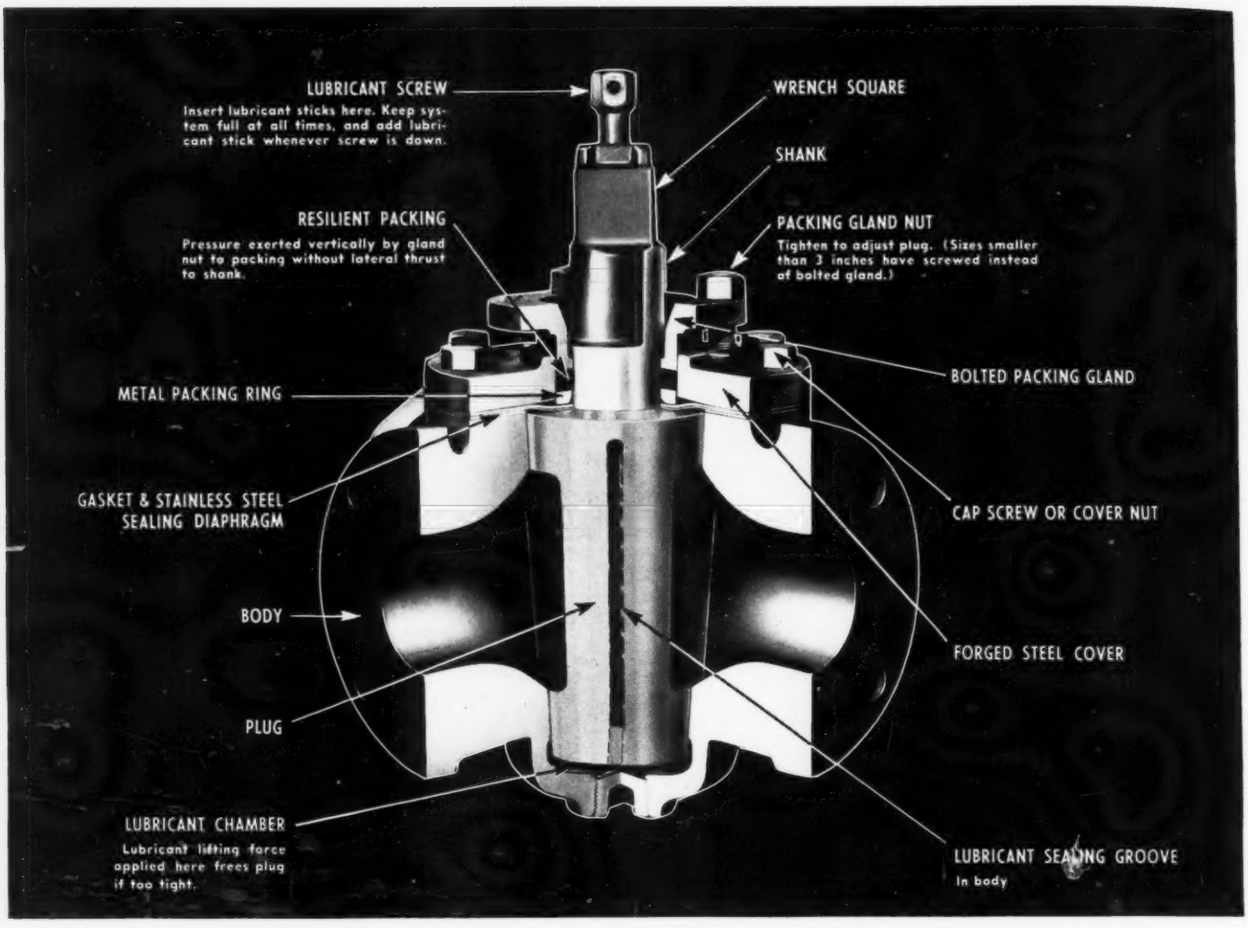
3-WAY, 3-PORT VALVE
90° TURN



3-WAY, 3-PORT VALVE
180° TURN

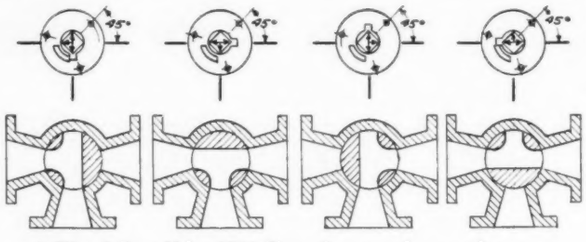
3-WAY, 3-PORT VALVE
270° TURN

...SWITCH TO NORDSTROMS


LUBRICANT SCREW
Insert lubricant sticks here. Keep system full at all times, and add lubricant stick whenever screw is down.
WRENCH SQUARE
SHANK
RESILIENT PACKING
Pressure exerted vertically by gland nut to packing without lateral thrust to shank.
PACKING GLAND NUT
Tighten to adjust plug. (Sizes smaller than 3 inches have screwed instead of bolted gland.)
BOLTED PACKING GLAND
METAL PACKING RING
GASKET & STAINLESS STEEL SEALING DIAPHRAGM
CAP SCREW OR COVER NUT
BODY
FORGED STEEL COVER
PLUG
LUBRICANT CHAMBER
Lubricant lifting force applied here frees plug if too tight.
LUBRICANT SEALING GROOVE
In body

LOOK WHAT YOU CAN DO WITH A NORDSTROM MULTIPORT VALVE

You can switch from one line to another instantly by operating only one Multiport Valve. One valve can do the work of two, three or four gate valves, according to the arrangement of flow-ways, ports and degrees of turn. There is a diversity of arrangements for turning the plug 90°, 180° and 270° to effect the various switching requirements. This means appreciable savings in initial installation costs, less valving, quicker turning, saving in time, more simplified switching. Nordstrom Multiport Valves are available in Standard or Hypreseal types with screwed or flanged openings. Sizes range from ½" to 24". Made in Semi-Steel, Nordco Cast Steel, Stainless Steel and special alloys. Bulletin V-135 gives full details. We'll gladly send it to you upon request.



3-Way, 3-Port Valve-270° Turn. One stop lug on plug stem. Cover and gland turned 180° from normal.

Nordstrom LUBRICATED VALVES

Sealdport Lubrication

MERCO NORDSTROM VALVE COMPANY – *A Subsidiary of Pittsburgh Equitable Meter Company*

WORLD'S LARGEST MANUFACTURERS OF LUBRICATED PLUG VALVES; GASOLINE, OIL & GREASE METERS

Main Offices: 400 Lexington Ave., Pittsburgh, Penna.

BRANCHES: New York City, Buffalo, Philadelphia, Columbia, Memphis, Chicago, Kansas City, Des Moines, Tulsa, Houston, Los Angeles, Oakland.

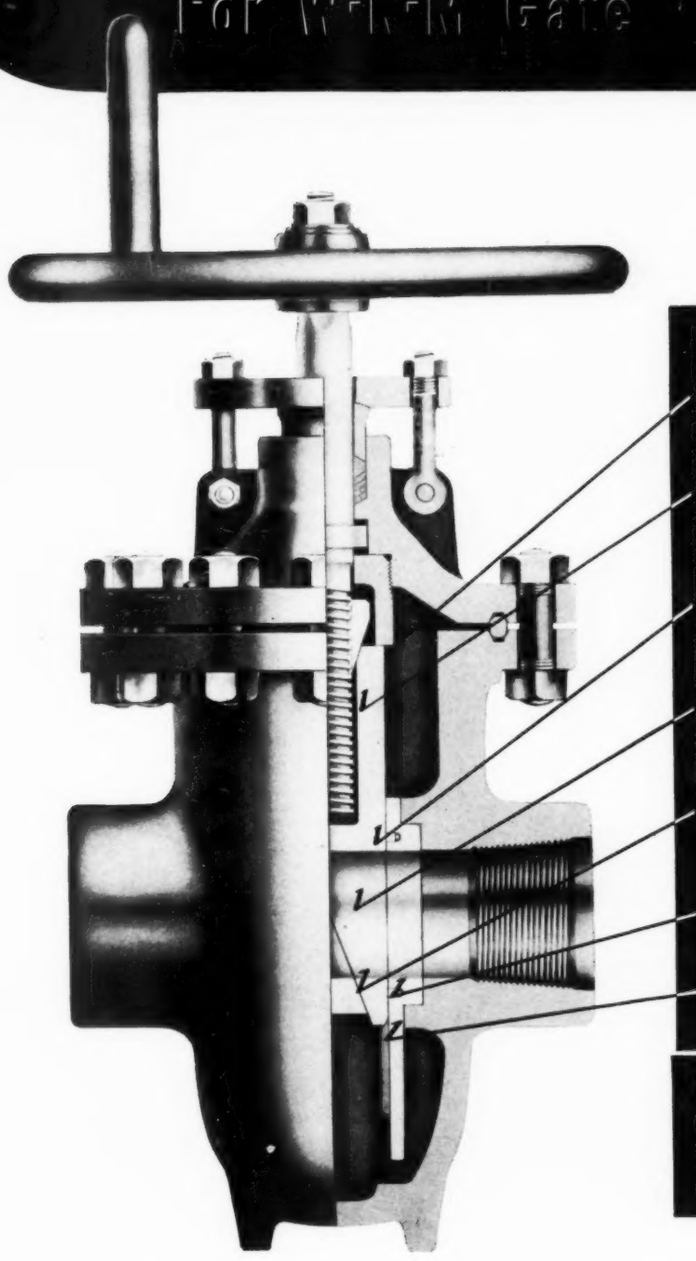
CANADIAN Licensees: Peacock Bros., Ltd., Montreal. • *EUROPEAN Licensees:* Audley Engineering Co., Ltd., Newport, Shropshire, England

SOUTH AMERICAN Representative: The Armco International Corporation. *Main Office:* Middletown, Ohio

PRODUCTS: Nordstrom Lubricated Valves; Air, Curb and Meter Cocks • Nordstrom Valve Lubricants • EMCO Gas Meters • EMCO-McGaughy Integrators EMCO Regulators • Pittsburgh-National Meters for Gasoline, Grease, Oil, Water and other Liquids • Raybould Couplings • Stupakoff Bottom Hole Gauges

CHECK THESE 7 REASONS

For W-K-M Gate Valve Success



Lubricant contained in entire body and bonnet assures easy operation and prevents internal corrosion

Parallel expanding gates mean a tight, positive shut-off every time, at full rated pressure

Combination wipe and seal rings keep the gate clean . . . the pressure out; the grease in

Pressure confined to smooth, through-conduit flow-way . . . no turbulence; no restriction of flow

No recess or seat cavity to collect sediment when open, or to prevent closing when desired

Seats not exposed in either closed or open position

Oversize renewable bronze seats

W-K-M Company, Inc.

OIL FIELD • PIPE-LINE & INDUSTRIAL EQUIPMENT

HOUSTON, Texas, U. S. A.

Export Office: 74 Trinity Place, New York

Cable Address: "WILKOMAC"

Costs No More Than Ordinary Valves • Sold Through Supply Stores Everywhere

NO COSTLY DELAYS IN DELIVERY OF THIS *POWER!*

"Reddy" is Ready to Work for You Now!

PROFIT! BY USING Utility ELECTRIC POWER

One important factor when considering power these days is to ascertain its availability so as to avoid any unnecessary delay in operations. By specifying Utility Electric Power, you can sidestep this problem, because it is one of the easiest and quickest types of power to adapt to your requirements. In other words, Reddy Kilowatt is ready to help you step up efficiency and increase profits now. Inquire at your Electric Power Service Company and get complete facts.

CONSULT YOUR ELECTRIC POWER COMPANY

When planning for power for Pipe Line Stations . . . Pumping . . . Refining . . . or Drilling purposes . . . why not call in your Electric Power Service Company's Sales Engineer. He can give you invaluable assistance and may save you thousands of dollars by helping you get the right power setup for your specific job!

Use Utility Electric Power!

PETROLEUM ELECTRIC POWER ASSOCIATION

4 MISSION VALVE FEATURES

insure perfect sealing, easy turning and longer valve life

1. Automatic Lubrication.*
2. Full-Port Lubricant Sealing Grooves.
3. Wedge-Proof cylindrical Super-Surfaced Core.
4. Sealing Grooves on Plug never pass Ports.

Leading drilling contractors and major oil companies have proven by actual competitive field tests that in all types of service Mission Plug Valves outwear and outlast other plug valves. • *If you want to reduce plug valve problems — and save money — make your next plug valve a Mission.*

1. **AUTOMATIC LUBRICATION**—Provides a constant lubricant seal • Line pressure automatically forces lubricant from reservoirs to sealing grooves • Eliminates necessity of frequent operation of lubricant screw • Ample downstream (sealing end) lubrication • Reduces friction — valve turns easily • Reduces wear and extends life of valve

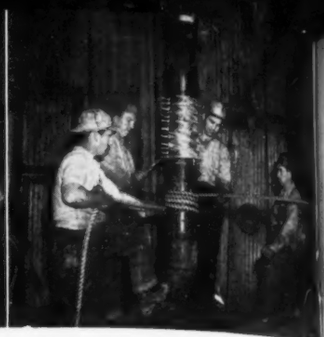
2. **FULL-PORT SEALING GROOVES**—Sealing grooves encircle ports — assures complete uniform seal • Provides a dependable seal against high pressures, liquid or gas • Full-Port Lubrication thoroughly lubricates core—valve operates easily • Reduces washouts • Reduces wear and extends life of valve

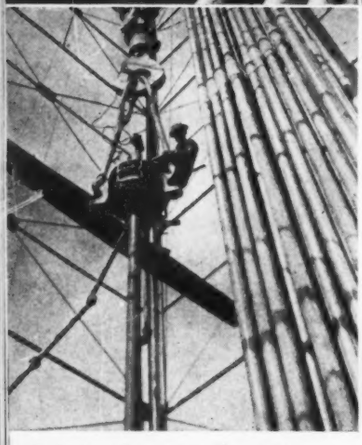
3. **WEDGE-PROOF SUPER-SURFACED CORE**—Cylindrical Core positively cannot wedge—permits easy turning • Perfect fit of core to body conserves lubricant and maintains leakproof seal longer • Lubricant lasts longer . . . saves time . . . saves valves • Super-Surfaced core provides extra resistance to abrasives and corrosion agents • Reduces wear — lasts longer

4. **SEALING GROOVES ON CORE**—Never exposed to fluid • Prevent loss of lubricant into fluid line . . . insures constant seal • Protects sealing grooves on core from direct cutting action of fluid • Lessens intrusion of abrasives into lubricant sealing grooves . . . reduces wear on vital sealing surfaces • Prolongs life of valve

*When lubricating a Mission Plug Valve, a portion of the lubricant is forced into reservoirs. Thereafter, the line pressure AUTOMATICALLY feeds this stored lubricant, as needed, into the downstream seal grooves. So long as lubricant remains in the reservoir a perfect seal is assured.

MISSION
MANUFACTURING CO.
HUMBLE ROAD • HOUSTON, TEXAS
EXPORT OFFICE: 30 ROCKEFELLER PLAZA, NEW YORK



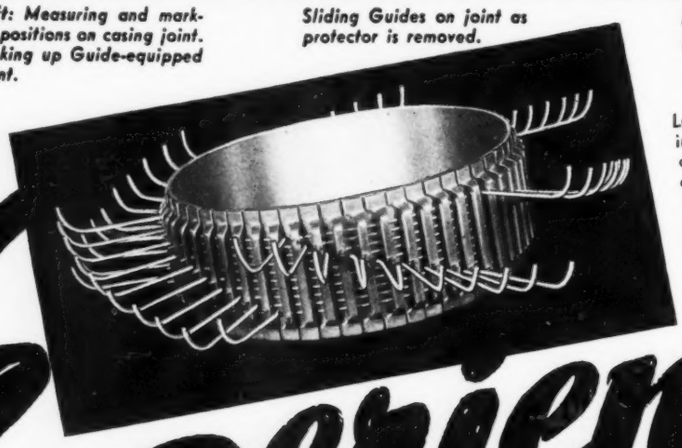


Releasing Cementing Plug. "Changing over" from cement to mud.

Above, left: Measuring and marking Guide positions on casing joint. Above: Picking up Guide-equipped bottom joint.

Sliding Guides on joint as protector is removed.

Making up Guide-equipped joint with spinning line.



Left: B and W Wall Cleaning Guides are assembled in collar form with oil-tempered spring steel wires mounted around each unit. The ingenious construction utilizes torque action in each wire to permit 180-degree movement of the wires without deformation.

THERE IS NO SUBSTITUTE FOR ..

Experience

B and W, Inc.

WALL CLEANING GUIDES

(Patents Applied For)

WITH SLOTTED LINERS

When a well strainer is landed in a hole full of rotary mud, this mud seriously interferes with the free entry of oil and gas. Present methods of washing, swabbing and bailing to remove the mud from slots, annulus, and wall are inadequate, and result in sand-cut liners and uneven withdrawal of oil from the sands of the producing section. The B and W Completion Method (Patent Pending) comprising Wall Cleaning Guides placed at intervals on the liner, coupled with a special wash assembly, makes it possible to mechanically break down and circulate out this mud and thus complete the well in ideal producing condition.

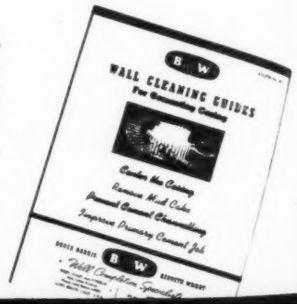
Pioneered IN MUD REMOVAL

THERE'S an obvious advantage to you in using a product made by the firm that was first in its particular field, for you get — in addition to the product itself — the benefit of their pioneering experience.

Our development period with B and W Wall Cleaning Guides is past, and hundreds of case histories—in all major oil fields—prove that B and W Guides are successfully performing their functions of: Centering Casing; Removing Mud Cake; Preventing Channeling; and Eliminating Expensive Re-cement Jobs.

RESULTS COUNT . . .

In our Bulletin No. 102 we have published a partial list of outstanding jobs, some of which are doubtless in your territory — also a list of fields in which B and W Guides have performed successfully. This Bulletin No. 102—which also contains full technical data, of course — is yours for the asking. *Write or telephone the B and W Office nearest you.*



WRITE FOR ILLUSTRATED BULLETIN 102

BRUCE BARKIS — B and W, Inc. — **KENNETH WRIGHT**

Well Completion Specialists

Makers of

Gulf Coast and Foreign Distributors of

NELSON PRE-PACKED GRAVEL LINERS • WILLIS ROTARY CHOKES

WEST COAST
3545 CEDAR AVE.
L. B. 4-8366
LONG BEACH
CALIFORNIA

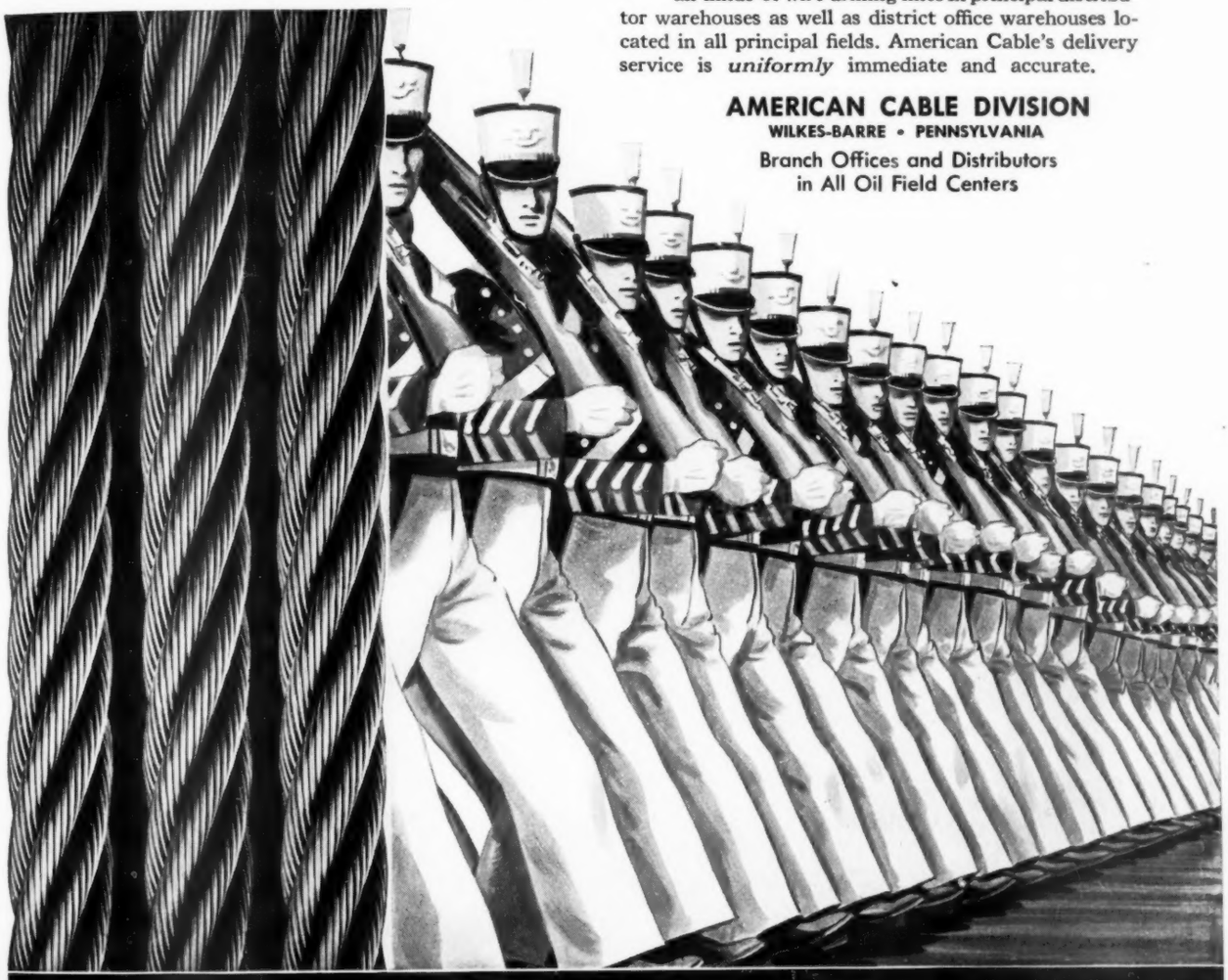
GULF COAST
1105 Commerce Bldg.
PRESTON 9783
HOUSTON
TEXAS

AMERICAN CABLE CRESCENT CABLE TOOL LINES *Are Uniform*

UNIFORM IN QUALITY This is a universally acknowledged characteristic of American Cable wire lines—by cable tool drillers everywhere.

UNIFORM IN SERVICE Being uniform in quality, American Cable's CRESCENT lines are naturally uniform in service. Literally thousands of cable tool drillers have found CRESCENT so uniformly high in enduring quality, well after well, that today—solely by word-of-mouth advice hundreds of other drillers are depending upon CRESCENT exclusively. *All* have long since learned that reel after reel of CRESCENT Non-Preformed lines are absolutely uniform in both metal and manufacturing quality. American Cable CRESCENT lines have *drillability*.

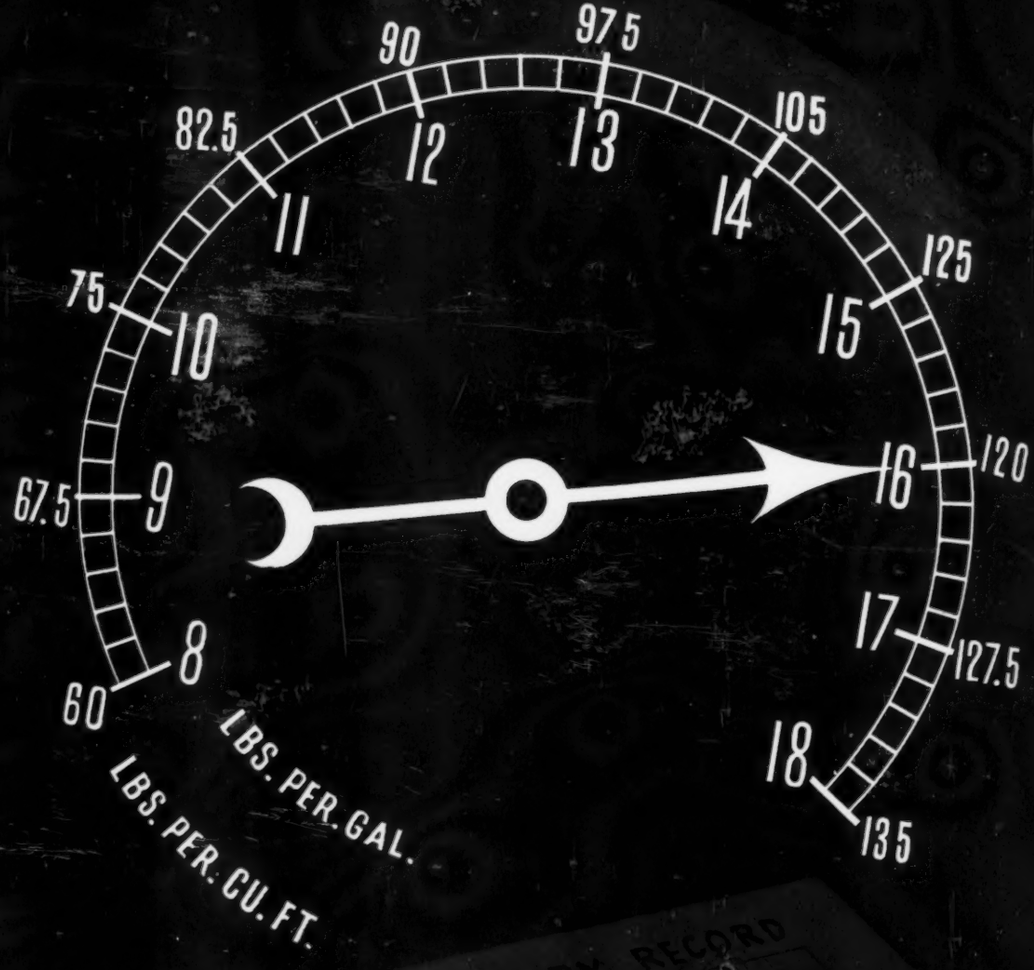
UNIFORM IN DISTRIBUTION The American Cable Division maintains large stocks of all kinds of wire drilling lines in principal distributor warehouses as well as district office warehouses located in all principal fields. American Cable's delivery service is *uniformly* immediate and accurate.



AMERICAN CABLE DIVISION
WILKES-BARRE • PENNSYLVANIA
Branch Offices and Distributors
in All Oil Field Centers

AMERICAN CHAIN & CABLE COMPANY, Inc.

ESSENTIAL PRODUCTS . . . AMERICAN CABLE Wire Rope, TRU-STOP Emergency Brakes, TRU-LAY Control Cables, AMERICAN Chain, WEED Tire Chains, ACCO Malleable Iron Castings, CAMPBELL Cutting Machines, FORD Hoists and Trolleys, HAZARD Wire Rope, Yacht Rigging, Aircraft Control Cables, MANLEY Auto Service Equipment, OWEN Springs, PAGE Fence, Shaped Wire, Welding Wire, READING-PRATT & CADY Valves, READING Electric Steel Castings, WRIGHT Hoists, Cranes, Presses . . . *In Business for Your Safety*



THE HOWCO Slurry Meter is a constant and accurate check on the kind of slurry being pumped into a well. Referring to it, the Howco cementer is able to hold rigidly to predetermined specifications. Control becomes a matter of fact.

HOWCO

SLURRY METER

"Taking the Guesswork out of Oil Well Cementing"

HALLIBURTON OIL WELL CEMENTING COMPANY